FINAL REPORT

REMEDIAL ACTION PLAN

Omaha Shops

ENVIRONMENTAL MANAGEMENT

Prepared for
Union Pacific Railroad Company
Omaha, Nebraska

August 1996

Woodward-Clyde

101 South 108th Avenue
Omaha, Nebraska 68154

91MC204

F I N A L   R E P O R T

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1.0
INTRODUCTION

1.1 AUTHORIZATION

This remedial action plan has been prepared for the Union Pacific Railroad Company (UPRR), Omaha Shops facility, by Woodward-Clyde (W-C). The Omaha Shops are located at 9th and Webster Streets in Omaha, Nebraska. The site encompasses approximately 184 acres, lying immediately west of the Missouri River in the Missouri River flood plain as shown on Figure 1-1. The Omaha Shops include various buildings and production support areas each having a function in past operations of the facility (see Figure 1-2).

1.2 REMEDIAL ACTION PLAN MONITORING ACT PROGRAM

On January 16, 1996, UPRR applied to participate in the Nebraska Remedial Action Plan Monitoring Act (RAPMA) Program. The RAPMA Program, authorized by the Legislature in 1994, allows the Nebraska Department of Environmental Quality (NDEQ) to coordinate and oversee efforts by property owners, prospective buyers, lending institutions, or others wishing to initiate voluntary environmental clean up activities. RAPMA was created to encourage redevelopment of abandoned commercial tracts of land and allows entities to voluntarily submit applications for participation in the program. The following key activities are expected to be included in potential Omaha Shops development activities under RAPMA:

- **Program Application:** UPRR obtained copies of the Application for Participation and Fees for Participation in the RAPMA Program from NDEQ. UPRR completed the application forms and submitted the initial application fee ($10,000 total) in January 1996.

- **Draft Remedial Action Plan:** UPRR has developed this draft remedial action plan to describe potential development acitivities for the Omaha Shops site. This plan outlines remedial objectives, environmental cleanup activities, and planned monitoring activities.

- **NDEQ Review:** NDEQ will review the remedial action plan and confer with UPRR regarding planned remedial objectives, environmental cleanup activities, and monitoring activities.

- **Final Remedial Action Plan:** UPRR will meet with NDEQ to resolve comments on the draft plan and to develop a final remedial action plan. The final plan will include development of an agreement between NDEQ and UPRR for reimbursement of NDEQ costs associated with monitoring remedial action activities.

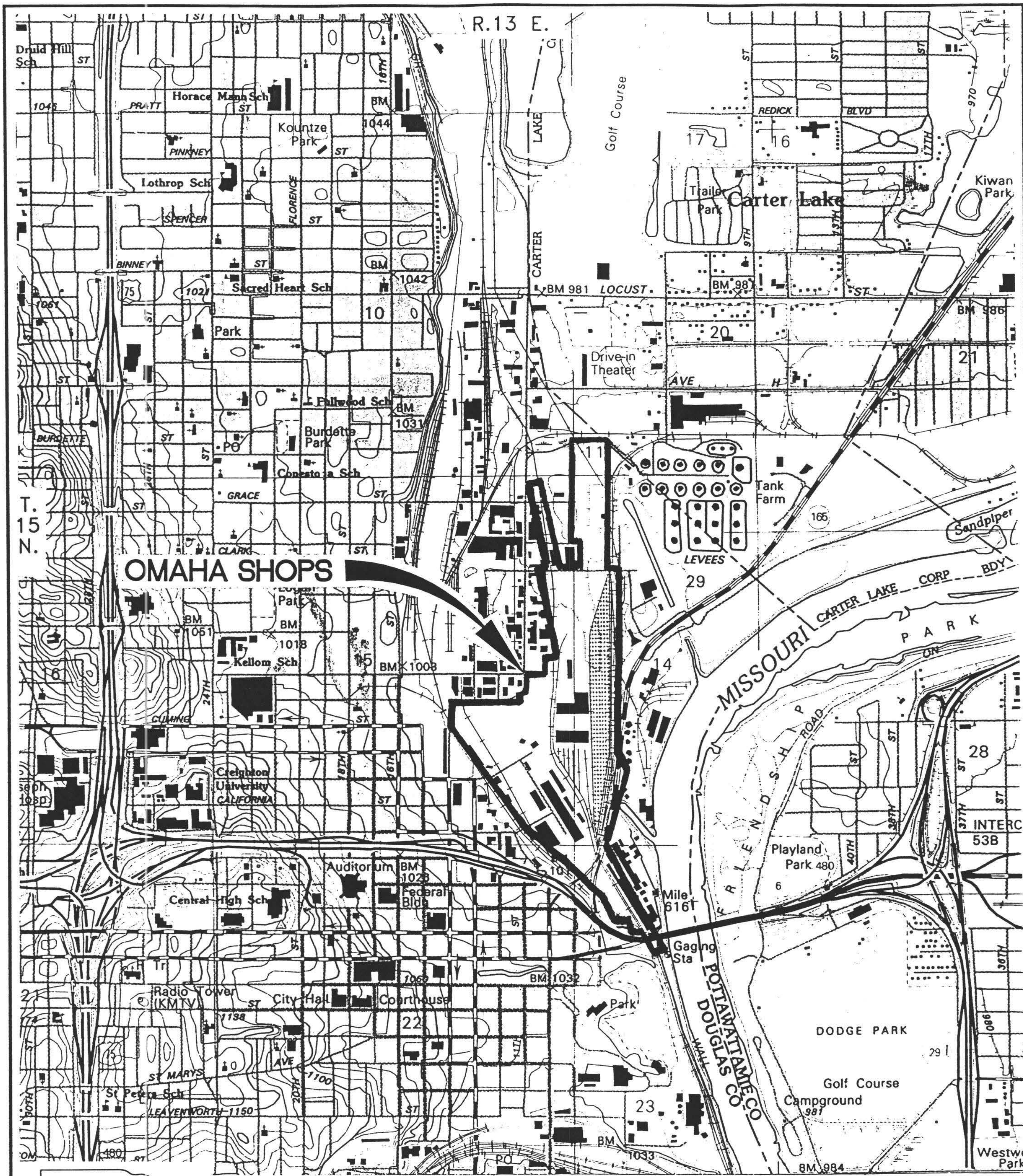
- **Remedial Action Plan Implementation:** Site development activities may begin following NDEQ approval of the final remedial action plan and execution of the monitoring implementation and cost reimbursement agreement between NDEQ and UPRR. NDEQ will monitor project activities to verify that site development activities are carried out as described in the remedial action plan. UPRR will submit periodic progress reports to NDEQ during implementation.

- **Remedial Action Completion:** UPRR will prepare a final report upon completion of the work described in the remedial action plan. NDEQ will review the plan to evaluate whether the site development activities meet the remedial action objectives described in the plan. NDEQ will also determine if all costs associated with monitoring the action have been recovered.

- **Letter of Completion:** When the outcome is satisfactory and no costs are outstanding, NDEQ will issue UPRR a letter of completion stating that "no further action need be taken at the site related to any contamination for which the remedial action has been taken in accordance with the approved remedial action plan".

1.3 PURPOSE

The purpose of this remedial action plan is to address the requirements of the RAPMA Program for voluntary environmental clean up of the Omaha Shops. The plan describes the remedial objectives and activities to be undertaken by UPRR to redevelop the Omaha Shops property for commercial use.



QUADRANGLE LOCATION

BASE MAP SOURCE: USGS 7.5 MINUTE SERIES (TOPOGRAPHIC) QUADRANGLE MAP OF OMAHA NORTH, NE.-IA., 1994.

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OMAHA SHOPS LOCATION

REMEDIAL ACTION PLAN
OMAHA SHOPS
UNION PACIFIC RAILROAD COMPANY

Woodward-Clyde

DRN. BY: SCR	DATE: 05/24/96	PROJECT NO.	FIG. NO.
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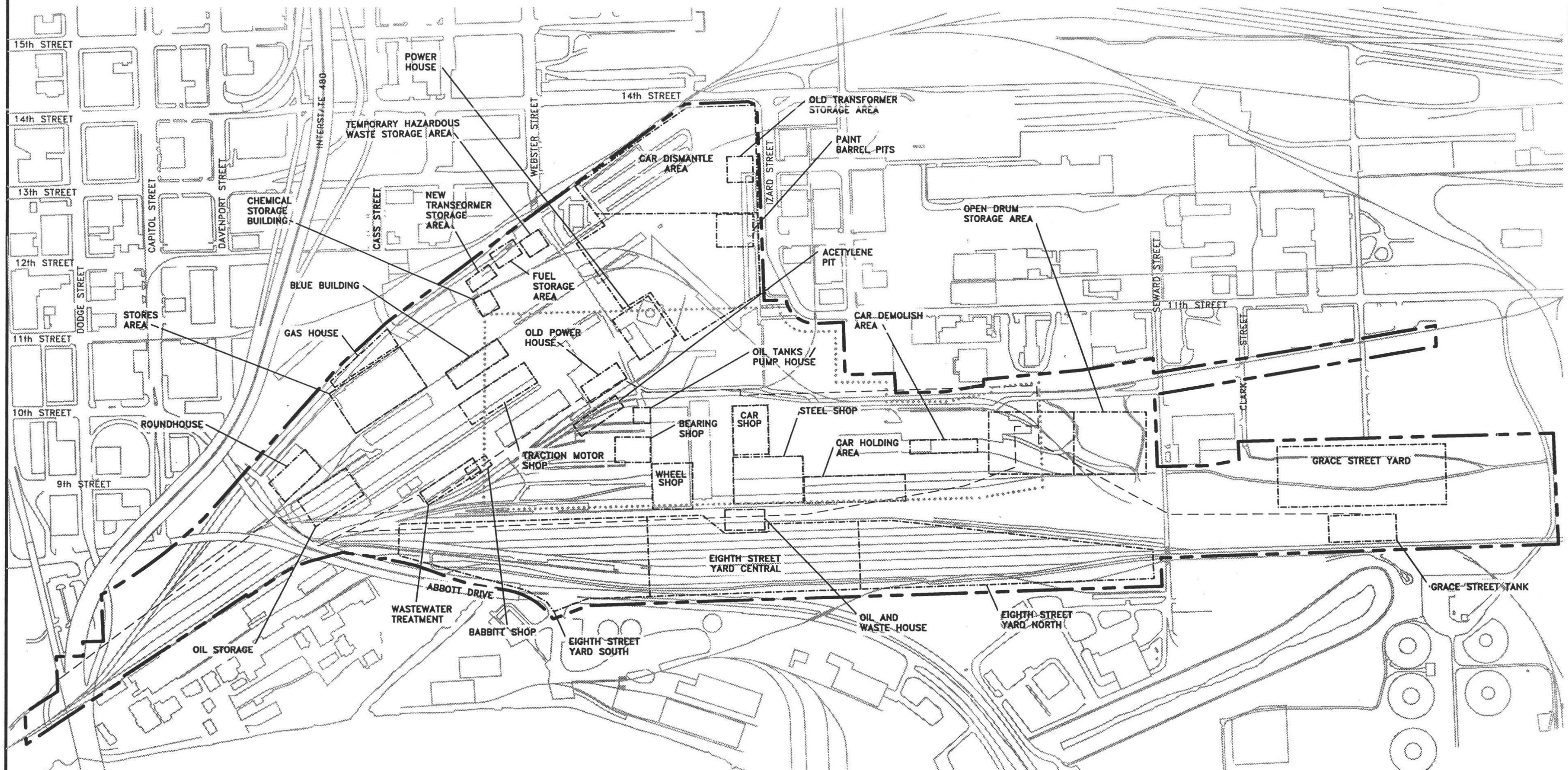

LEGEND

STRUCTURES

RAILROAD TRACK

PROPERTY LINE

OIL PIPELINE

CONSTRUCTION AREA

HDR STUDY OPERATIONAL AREAS

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SITE PLAN

REMEDIAL ACTION PLAN
OMAHA SHOPS
UNION PACIFIC RAILROAD COMPANY

Woodward-Clyde

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2.0
SITE BACKGROUND

The UPRR Omaha Shops are located north of downtown Omaha in Douglas County, Nebraska. UPRR is in the process of closing operations at the facility. Locomotive repair and maintenance activities at the Omaha Shops were ended in 1988. Limited rail car maintenance activities remain.

The Omaha Shops were in operation for approximately 100 years, with principal functions as a railroad fueling facility, repair shop, paint shop, and car body repair shop for UPRR's locomotive and car fleet. Shop operations were divided into the following two major areas of responsibility:

- Locomotive Shop - Primary purpose was to repair worn or damaged component parts from locomotive units on the UPRR system.

- Car Department - Primary purpose was to repair and modify freight cars, business cars and cabooses, with some new car construction.

The ground surface at the site is nearly level. Surface drainage is primarily to the east, toward the Missouri River. Surface elevation of the site is approximately 985 feet above mean sea level (msl). The Omaha Shops are about 10 to 15 feet above normal river stage.

Shallow unconsolidated deposits at the site are characterized by fill and alluvium. Previous investigations at and near the site indicate that fill ranges in thickness from 1 to 9 feet with the thickest fill near the river channel. The fill consists of cinders, bricks, glass, metal, and gravel in a matrix of silt (HDR 1990). Alluvial deposits consisting of interbedded clay, silt, sand and gravel underlie the fill. The alluvial sequence lies above bedrock which is about 20 to 50 feet below the ground surface (UPRR 1984).

Bedrock is of the Pennsylvanian age and consists of alternating beds of limestone and shale. Three different formations are normally encountered in this location; the Wyandotte Limestone, the Lane Shale, and the Iola Limestone. These formations are of the Kansas City group of the Missouri series (UPRR 1984).

Shallow groundwater is encountered at the site at depths ranging from approximately 3 to 15 feet below ground surface. Groundwater appears to flow northeasterly, with a calculated hydraulic gradient in the direction of flow estimated to be about 0.01 feet per foot (HDR 1990). The alluvial sediments are expected to have a low hydraulic conductivity with a range of 0.3 to 0.003 feet per day. Hydraulic recharge is likely from surface infiltration due to the porous characteristics of the surface fill materials (UPRR 1984).

2.1 PREVIOUS INVESTIGATIONS

Studies and investigations previously completed at the Omaha Shops are briefly described below.

2.1.1 Preliminary Investigations and Studies

In 1987 and 1988, United States Pollution Control Inc. (USPCI) completed a PCB electrical transformer fluid survey at the Omaha Shops. According to the survey results, 57 transformers were identified as containing PCB fluids. Concentrations ranged from 0.3 ppm to 932 ppm PCBs. At the time of the survey, 12 of the 57 transformers were in service; three of the 12 transformers contained PCBs at concentrations greater than 240 ppm (241, 254, and 440 ppm), and the remaining nine transformers had PCB concentrations of less than 60 ppm (49, 48, 51, 56, 46, 52, 39, 48, 51 ppm). The remaining 45 transformers identified as containing PCB fluids were removed from service or disposed of by USPCI (USPCI 1988a).

SOS International completed an asbestos survey of the Omaha Shops in 1988. SOS collected 14 samples of suspected asbestos-containing building materials (ACBM). Six of these samples tested positive for asbestos with concentrations ranging from 35 percent to 90 percent chrysotile asbestos. Ten samples were collected from the outside steam line insulation. Five of these samples contained asbestos. Pipe insulation was examined in the North Locker Room and one sample was collected. The sample contained 90 percent chrysotile asbestos. The Power House pipe insulation and boiler area sampling involved collecting two samples, both of which were found not to contain asbestos. A spray-applied material observed on the walls of Store No. 2 was suspected of containing asbestos, and one sample was collected. This sample was found not to contain asbestos (SOS 1988).

USPCI completed a preliminary site assessment of the Omaha Shops in 1988. The assessment included a facility walk-through and historical records search. Results of the survey identified a number of current and historical areas which were considered to be areas of potential environmental concern (USPCI 1988b).

2.1.2 Fuel Recovery System

A diesel fuel recovery system was installed in 1988 by Terracon. During construction of the Abbott Drive overpass, diesel fuel was discovered on the groundwater near the south end of the Omaha Shops. A total of 13 recovery wells were installed at depths of approximately 27 to 28 feet (Terracon 1988). The system continues to operate, removing approximately 770 gallons of diesel fuel per month (USPCI/Laidlaw 1996).

2.1.3 Phase I Site Assessment

HDR Engineering, Inc. (HDR) completed a Phase I site assessment of the Omaha Shops in 1989 and 1990 as a follow-up assessment to the USPCI preliminary site assessment. Field investigations included hand auger borings, truck-mounted drill rig borings, monitoring well installation and sampling, and soil vapor analysis. The investigation identified 16 areas as exhibiting "positive" results for the presence of contamination. Groundwater and soil contaminant levels were compared to selected maximum allowable levels to evaluate whether further action was necessary (HDR 1990). The report concluded that the following areas may require remediation if the site is developed:

- Several areas exhibited elevated petroleum hydrocarbon levels:
  - Stores No. 2
  - Wastewater Treatment Area/Babbitt Shop
  - Traction Motor Shop
  - Oil Tanks/Pump House
  - Grace Street Tank
  - Oil Pipeline (selected locations)

- Soil lead levels exceeded 1,000 ppm in the following areas:

  - Babbitt Shop
  - Paint Barrel Pits (also exceeded EP Toxicity levels for lead)
  - Open Drum Storage Area North
  - Eighth Street Yard South

- Semivolatile organic compounds (SVOC) volatile organic compounds (VOC) were detected at several areas

- Soil asbestos levels were greater than 1 percent in the Car Dismantle Area and Open Drum Storage Area

- Groundwater maximum contaminant levels (MCLs) for metals, VOCs, and SVOCs were exceeded in monitoring wells at the following seven operational areas:

  - Roundhouse (VOCs, selenium)
  - Wastewater Treatment Area/Babbitt Shop (lead)
  - Traction Motor Shop (SVOCs, arsenic, selenium)
  - Open Drum Storage Area (lead, selenium, VOCs)
  - Car Demolish Area (selenium)
  - 8th Street Yard (selenium)
  - Grace Street Yard (selenium, VOCs)

2.1.4 Phase II Site Assessment

In December 1992, the Omaha Shops property became a candidate site for construction of an automobile assembly facility. The area of the Omaha Shops property that would be affected by construction of the proposed manufacturing facility and relocation of existing large-diameter sewers underlying the area was investigated. The Construction Area Phase II Site Assessment (W-C 1995) found low levels of metals, VOCs, SVOCs, pesticides/PCBs, and petroleum hydrocarbons (TPH) in the soil. The Construction Area Phase II Site Assessment concluded that:

- The low levels of VOCs, SVOCs, pesticides/PCBs, and TPH detected in the soil samples from the Construction Area are not likely to represent a serious threat to human health or the environment. Selected compounds are present, however, at levels that may require further evaluation.

- Most of the metals detected in the soil samples from the Construction Area are present at concentrations that are not likely to represent a serious threat to human health or the environment. Selected metals (i.e., arsenic, chromium, and lead) are present, however, at levels that may require further evaluation.

The report recommended that a screening-level risk assessment be completed to evaluate whether chemicals detected in the Construction Area could potentially pose an unacceptable risk to human health. The results of the screening-level risk assessment would be used to evaluate the necessity and scope of potential corrective action for the site. (W-C 1995)

2.2 SCREENING-LEVEL RISK ASSESSMENT

The purpose of the screening-level risk assessment (W-C 1994) was to determine if chemicals in soils at the Omaha Shops are present at concentrations that could pose potential human health risks. The screening-level risk assessment was completed by comparing concentrations detected in soils at the site with conservative risk-based concentrations (RBCs). RBCs are soil concentrations that, with conservative exposure assumptions, would not be expected to result in unacceptable human health risks. For the evaluation, RBCs were calculated for construction workers, occupational workers, and child recreational receptors based on conservative assumptions of exposure and target risk values. Actual exposures to contaminants at the site are expected to be much lower.

Concentrations detected at 31 sites at the facility were compared to calculated RBCs. RBCs were derived for chemicals detected in soil at the 31 sites (field investigations for 30 of the sites were conducted by HDR [1990] and for one site [Construction Area] by Woodward-

Clyde [W-C 1995]). Metals which were determined to be above critical background values and any detected organic compounds were compared to the RBCs.

Thirteen of the Omaha Shops sites did not have any chemical concentrations which exceeded the RBCs for occupational workers, construction workers, and child recreational receptor scenarios. No soil samples were collected at the Fuel Storage Area; therefore, no RBC comparison could be made for the site. The 13 sites with no chemical concentrations exceeding RBCs include the following operational areas:

- Gas House
- Stores Area
- New Transformer Storage Area
- Chemical Storage Building
- Old Traction Motor Shop
- Oil Tanks/Pump House
- Bearing Shop
- Wheel Shop
- Oil and Waste House
- Old Transformer Storage Area
- Car Shop
- Grace Street Tank
- Oil Pipeline

Fourteen of the sites had chemical concentrations which exceeded one or more RBCs by less than a factor of ten for occupational workers, construction workers, and child recreational receptor scenarios. These 14 sites include the following operational areas:

- Roundhouse
- Oil Storage
- Wastewater Treatment/Babbitt Shop

- Traction Motor Shop
- Acetylene Pit
- Power House
- Temporary Hazardous Waste Storage
- Car Dismantle Area
- Paint Barrel Pits
- Steel Shop
- Car Holding Area
- Car Demolish
- Open Drum Storage
- Grace Street Yard

Three sites had chemical concentrations that exceeded one or more RBCs by greater than a factor of ten. These three sites include the following:

- At the north area of the Eighth Street Yard, arsenic concentrations exceeded the recreational and occupational RBCs by factors of 12 and 19 times, respectively. At the south area of the Eighth Street Yard, arsenic concentrations exceeded the recreational and occupational RBCs by factors of 24 and 37 times, respectively.

- Arsenic concentrations in the surface soils at one sampling location in the Construction Area exceeded the recreational and occupational RBCs by factors of 17 and 26 times, respectively.

- Tetrachloroethene (PCE) concentrations in the soil at the Storage Tank Area near the Blue Building exceeded the occupational RBC by a factor of about 700.

Estimated lifetime excess cancer risk associated with the arsenic concentrations, based on comparison to RBCs is within the EPA's target risk range of 1×10^{-6} to 1×10^{-4} for exposures to chemicals released from hazardous waste sites (EPA 1991a). Considering that actual recreational or occupational exposures to contaminated soil would be much lower than those assumed for RBCs, significant human health risks from exposure to arsenic would not be expected in the Eighth Street Yard or the Construction Area.

The PCE concentrations observed in the soil at the Storage Tanks near the Blue Building may be high enough to warrant further evaluation of the site. Earlier efforts to confirm the presence of PCE in the soil in this area failed to detect PCE; therefore, the high PCE concentration is highly suspect and is not considered a significant health risk.

2.3 SUMMARY OF SITE ENVIRONMENTAL CONDITIONS

Based on the results of previous investigations and studies, environmental conditions at the Omaha Shops are summarized below:

- **Groundwater:** Metals, VOCs, and SVOCs were detected in several monitoring wells at the Omaha Shops. Considering the industrial setting of the site and the lack of beneficial use of groundwater in the area, groundwater remediation is not expected to be required.

- **Organic Chemicals in Soil:** The low levels of VOCs, SVOCs, and pesticides/PCBs detected in soil samples from the Omaha Shops are not likely to represent a serious threat to human health or the environment. Some organic chemicals are present, however, at levels that may require further evaluation.

- **Metals in Soil:** Most of the metals detected in the soil samples from the Omaha Shops are present at concentrations that are not likely to represent a serious threat to human health or the environment.

- **Arsenic in Soil:** Arsenic is present in the soil at concentrations exceeding RBCs for occupational and recreational exposures in several areas of the

Omaha Shops property. Arsenic was found at levels that exceed RBCs by greater than a factor of ten in the following areas:

- Arsenic was detected at 300 milligrams per kilogram (mg/kg) in the surface soil sample from Construction Area soil boring SB-15. This concentration exceeds the recreational and occupational RBCs by factors of 17 and 26 times, respectively.

- At the north area of the Eighth Street Yard, the arsenic concentration (215 mg/kg) exceeds the recreational and occupational RBCs by factors of 12 and 19 times, respectively. At the south area of the Eighth Street Yard, the arsenic concentration (419 mg/kg) exceeds the recreational and occupational RBCs by factors of 24 and 37 times, respectively.

Arsenic concentrations in soil at the Omaha Shops are summarized in the following figures:

- Figure 2-1 Arsenic Concentrations in Surface Soil - Operational Areas

- Figure 2-2 Arsenic Concentrations in Surface Soil - Construction Area

- Figure 2-3 Arsenic Concentrations in Shallow Soil - Construction Area

• **Lead in Surface Soil:** Lead is present in the surface soil at concentrations exceeding EPA's recommended acceptable range of 500 to 1,000 mg/kg in the following areas:

  - Babbitt Shop - 1,655 mg/kg (composite sample)
  - Open Drum Storage Area - 2,450 mg/kg (composite sample)

– Eighth Street Yard South - 5,549 mg/kg (composite sample)

– Construction Area - SB-03: 1,600 mg/kg

SB-11: 1,300 mg/kg

SB-14: 1,800 mg/kg

SB-15: 1,600 mg/kg

Since the screening-level risk assessment was completed in 1994, the EPA has issued guidance on assessing lead exposure and risk from industrial and commercial land use where only adults are exposed. For lack of a better approach, many agencies have used the upper end of the 500 to 1,000 mg/kg cleanup range (specified in EPA's 1989 guidance for lead at residential sites where children are exposed) to establish cleanup levels for industrial and commercial sites where only adults are exposed. This cleanup level range is not health-based for adult exposure because it was developed based on blood lead levels in children who have much higher soil ingestion rates, lead uptake rates, and resultant blood lead levels than similarly exposed adults.

EPA's Technical Review Workgroup for Lead (TRW) has developed interim guidance for assessing lead risks and establishing cleanup goals that will protect adults and fetuses from lead in soil (EPA 1995). The guidance does not provide a specific target soil lead cleanup level, but proposes a methodology which allows for the input of either site-specific data or recommended default values to assess risk and develop site-specific cleanup goals. The methodology is very conservative (health-protective) because it is designed to protect developing fetuses, who may be more sensitive to the effects of lead than are adults. Therefore, cleanup goals developed using this methodology are much lower than those required for protection of adults only. Because the methodology used to derive the action level was only recently developed, detailed discussions of the methodology and associated rationale are provided in Appendix A.

An action level of 2,725 mg/kg lead in soil was derived for the Omaha Shops assuming a commercial worker scenario for adults, potentially including pregnant women. The action level was derived based on assumptions regarding soil ingestion, lead uptake, and resulting blood lead levels in adults (rather than in children). Therefore, the action level is a more appropriate estimate of health-protective cleanup levels for adult and fetal exposure to lead in soil than are levels selected from the generic 500 to 1,000 mg/kg range derived by EPA-based on blood lead levels in children.

Lead concentrations in surface soil at the Omaha Shops are summarized in the following figures:

- Figure 2-4 Lead Concentrations in Surface Soil - Operational Areas
- Figure 2-5 Lead Concentrations in Surface Soil - Construction Area

- **Petroleum Hydrocarbons in Soil and Groundwater:** Petroleum hydrocarbons are present in the soil at concentrations exceeding RBCs in two areas of the Omaha Shops property:

  - Petroleum hydrocarbons were detected at 214,466 mg/kg (as brake, hydraulic, and transmission fluid) in sample A4, which was collected in the south portion of the Wastewater Treatment Area. This concentration exceeds recreational, occupational, and construction RBCs for petroleum hydrocarbons by factors of 9, 4, and 2, respectively.

  - Petroleum hydrocarbons were detected at 27,992 mg/kg (as No. 2 diesel) in the Traction Motor Shop area. This concentration exceeds the recreational RBC for petroleum hydrocarbons by less than a factor of 2.

Petroleum hydrocarbon concentrations in soil at the Omaha Shops are summarized in the following figures:

- Figure 2-6 Petroleum Hydrocarbon Concentrations in Soil - Operational Areas

- Figure 2-7 Petroleum Hydrocarbon Concentrations in Soil - Construction Area

Free-phase diesel is present on the groundwater in the area south of the former locomotive fueling and servicing area (see Figures 2-6 and 2-7).

- **Paint Barrel Pits:** Arsenic, lead, and SVOCs were detected in soil samples from the paint barrel pits at concentrations exceeding one or more RBCs:

  - Arsenic was detected at 31 mg/kg and 21 mg/kg. These concentrations exceed the recreational and occupational RBCs by factors of less than 10.

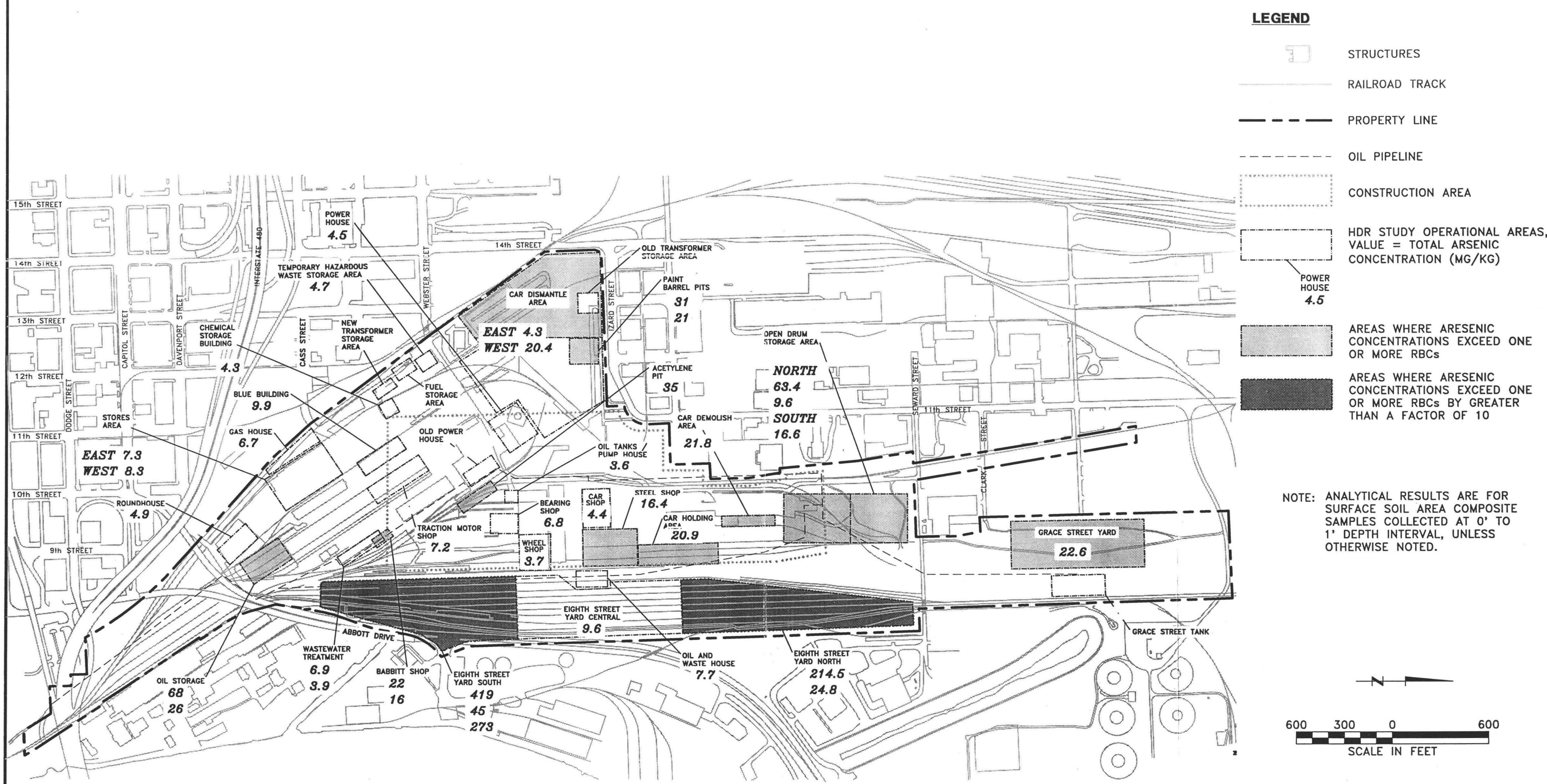
  - Lead was detected at 7,800 mg/kg and 4,600 mg/kg in composite soil samples from the paint barrel pits. These concentrations exceed EPA's recommended acceptable range of 500 to 1,000 mg/kg. One soil sample was analyzed for extraction procedure (EP) toxicity. The results for this sample (41 milligrams per liter [mg/l] lead) exceeded the regulatory EP toxicity level for lead (5 mg/l).

  - SVOCs benzo(a)anthracene and benzo(a)pyrene were detected at concentrations of 25 mg/kg and 20 mg/kg, respectively, in a composite soil sample from the paint barrel pits. These concentrations exceeded recreational and occupational RBCs by less than a factor of 10.

- **Asbestos in Surface Soils:** Soil samples collected during the Phase I Site Assessment indicated a random distribution of low levels of asbestos throughout the Car Dismantle Area. Asbestos fibers were detected at levels greater than 1 percent in 9 of 31 samples analyzed. Twelve soil samples were collected at other random locations on the Omaha Shops site. Asbestos fibers were detected at greater than 1 percent asbestos in only one of these 12 samples, located northwest of the Open Drum Storage Area.

One surface soil sample for asbestos analysis was collected at each of the 19 soil borings drilled for the Construction Area investigation. Asbestos fibers were detected at 2 percent in 4 of the 19 samples analyzed (soil borings SB02, SB03, SB10, and SB13). Asbestos levels in soil at the Omaha Shops are summarized in the following figures:

- Figure 2-8 Asbestos Levels in Surface Soil - Operational Areas
- Figure 2-9 Asbestos Levels in Surface Soil - Construction Area



ARSENIC CONCENTRATIONS IN SURFACE SOIL–OPERATIONAL AREAS

UNION PACIFIC

REMEDIAL ACTION PLAN
OMAHA SHOPS
UNION PACIFIC RAILROAD COMPANY

Woodward-Clyde

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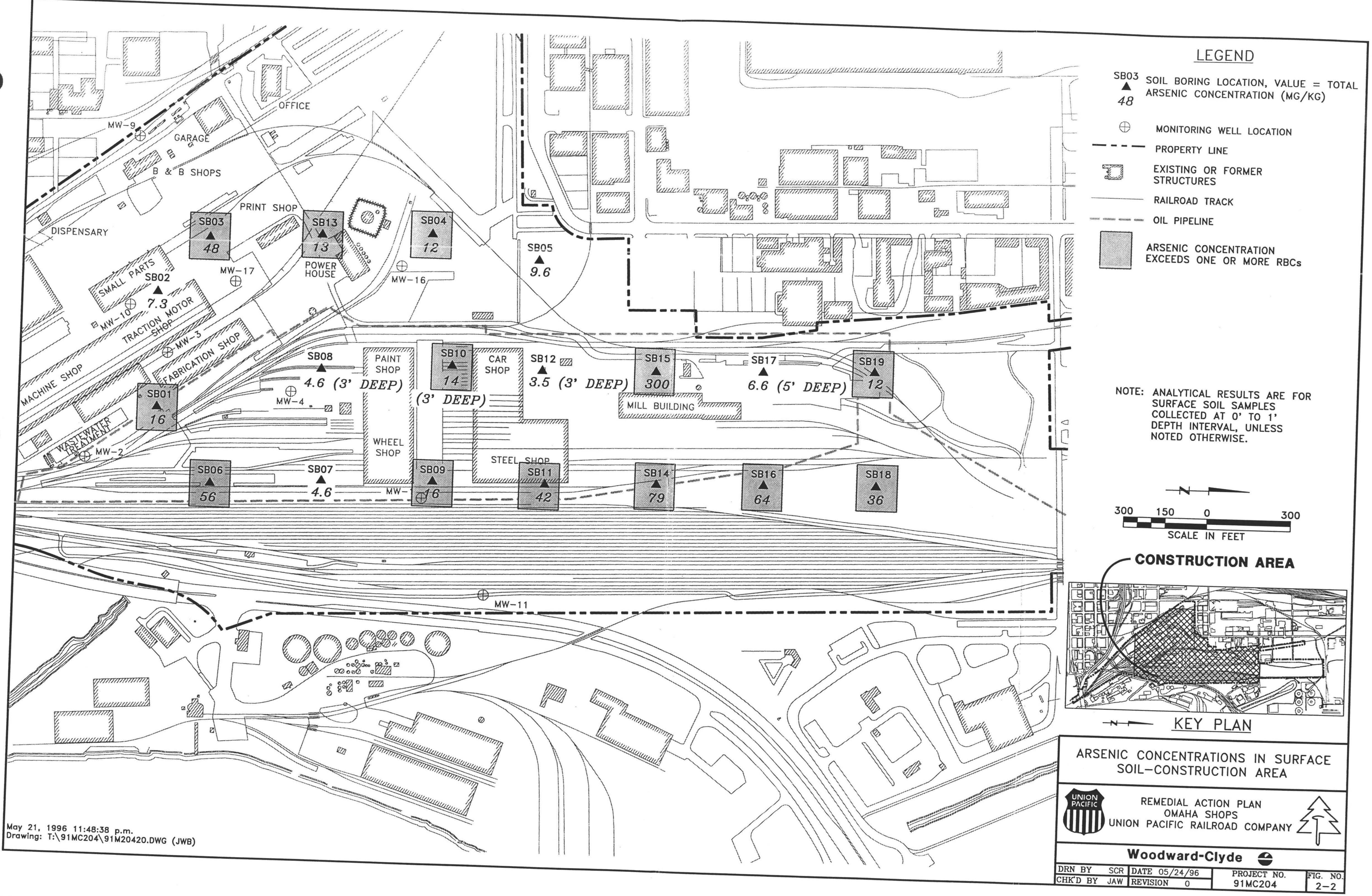

LEGEND
SB03 48 SOIL BORING LOCATION, VALUE = TOTAL ARSENIC CONCENTRATION (MG/KG)
MONITORING WELL LOCATION
PROPERTY LINE
EXISTING OR FORMER STRUCTURES
RAILROAD TRACK
OIL PIPELINE
ARSENIC CONCENTRATION EXCEEDS ONE OR MORE RBCs
NOTE: ANALYTICAL RESULTS ARE FOR SURFACE SOIL SAMPLES COLLECTED AT 0' TO 1' DEPTH INTERVAL, UNLESS NOTED OTHERWISE.
OFFICE
MW-9
GARAGE
B & B SHOPS
PRINT SHOP
DISPENSARY
SB03 48
SB13 13
POWER HOUSE
SB04 12
SB05 9.6
MW-17
MW-16
SMALL PARTS
SB02 7.3
MW-10
TRACTION MOTOR SHOP
MW-3
FABRICATION SHOP
MACHINE SHOP
SB01 16
WASTEWATER TREATMENT
MW-2
MW-4
SB08 4.6 (3' DEEP)
PAINT SHOP
SB10 14 (3' DEEP)
CAR SHOP
SB12 3.5 (3' DEEP)
SB15 300
MILL BUILDING
SB17 6.6 (5' DEEP)
SB19 12
WHEEL SHOP
STEEL SHOP
SB06 56
SB07 4.6
MW-
SB09 16
SB11 42
SB14 79
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SB18 36
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ARSENIC CONCENTRATIONS IN SURFACE SOIL-CONSTRUCTION AREA
UNION PACIFIC
REMEDIAL ACTION PLAN
OMAHA SHOPS
UNION PACIFIC RAILROAD COMPANY
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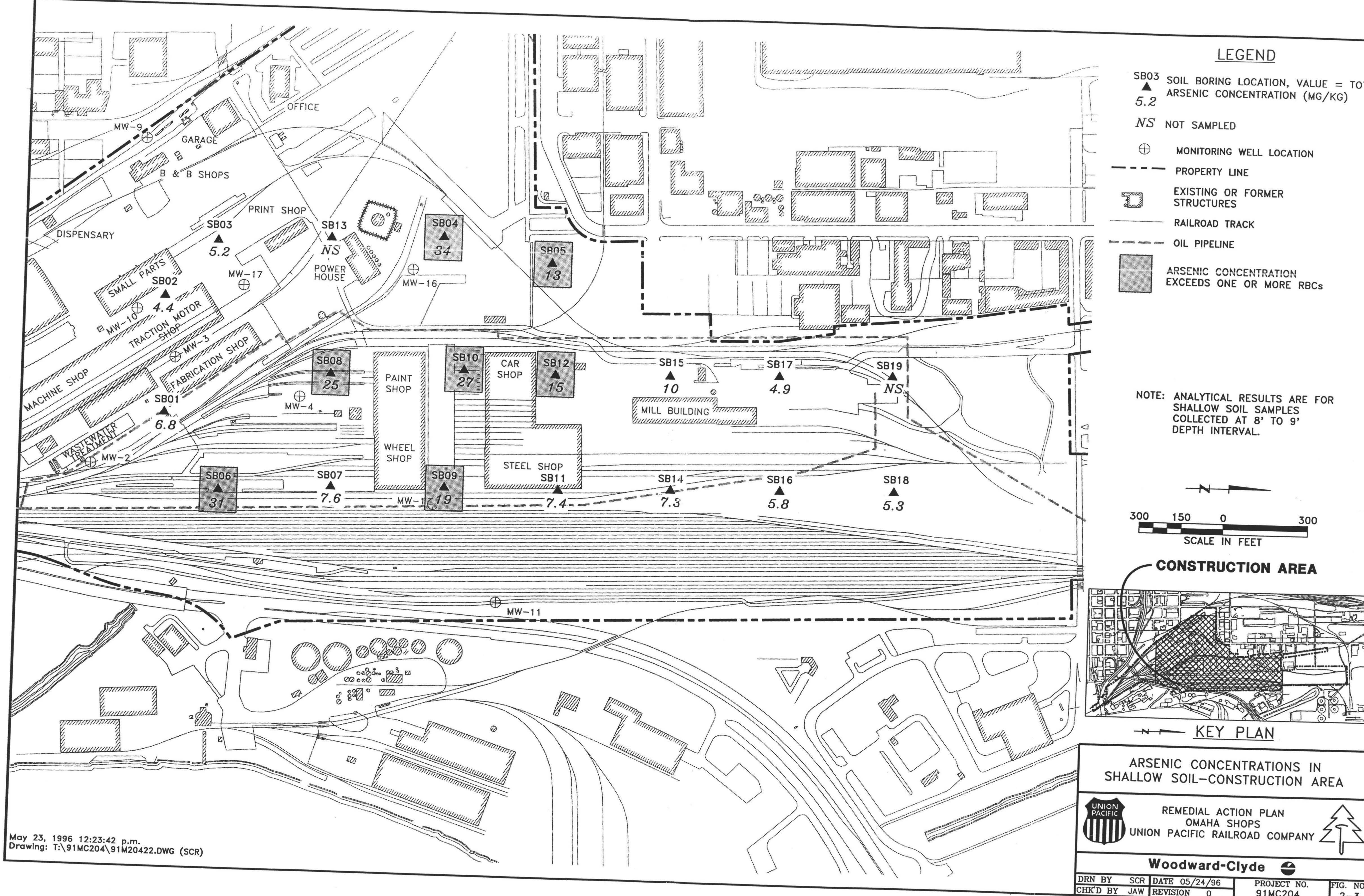

ARSENIC CONCENTRATIONS IN SHALLOW SOIL-CONSTRUCTION AREA

REMEDIAL ACTION PLAN
OMAHA SHOPS
UNION PACIFIC RAILROAD COMPANY

Woodward-Clyde

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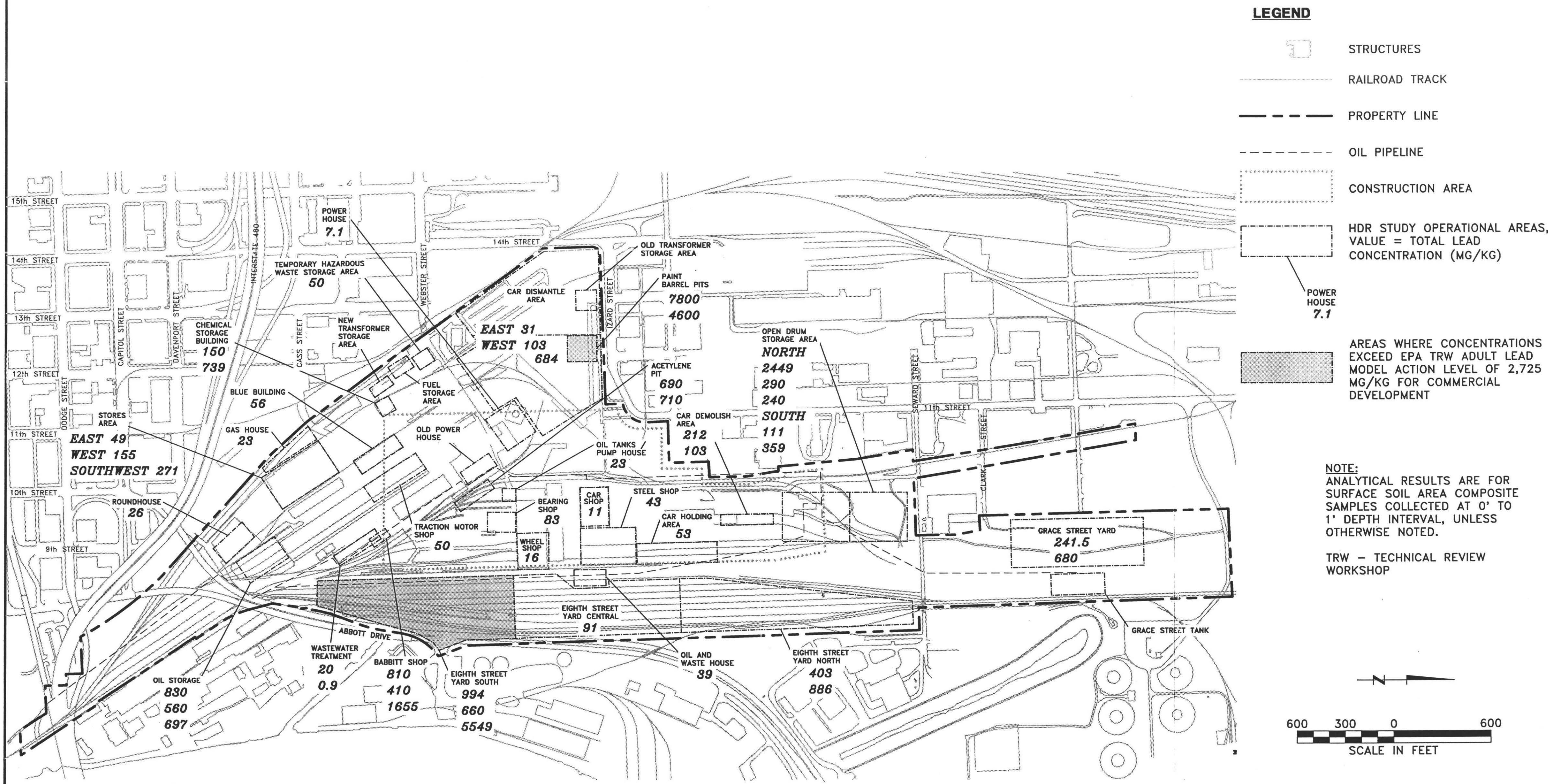

LEAD CONCENTRATIONS IN SURFACE SOIL–OPERATIONAL AREAS

REMEDIAL ACTION PLAN
OMAHA SHOPS
UNION PACIFIC RAILROAD COMPANY

Woodward-Clyde

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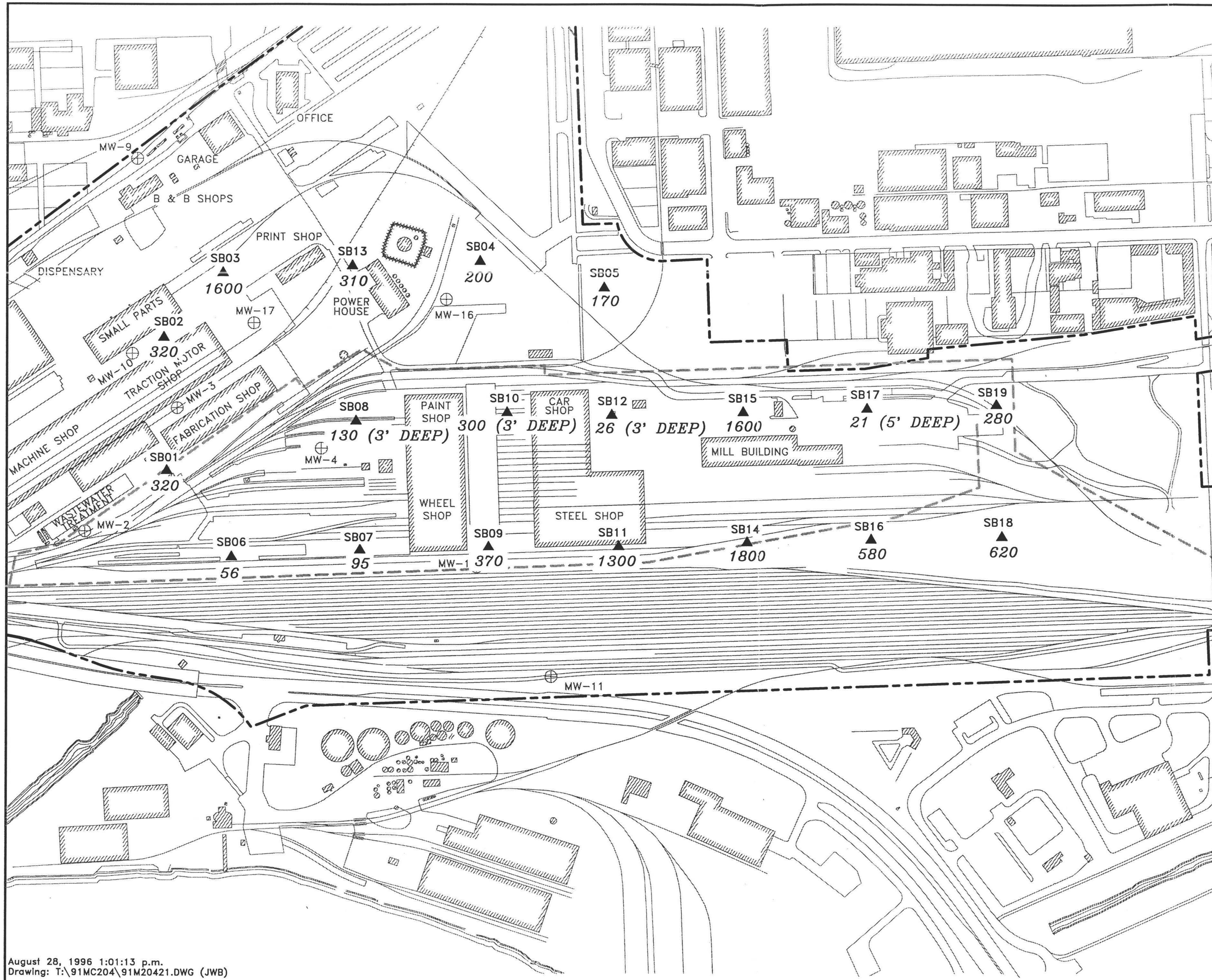

LEGEND

SB03 ▲ 1600 — SOIL BORING LOCATION, VALUE = TOTAL LEAD CONCENTRATION (MG/KG)

⊕ — MONITORING WELL LOCATION

PROPERTY LINE

EXISTING OR FORMER STRUCTURES

RAILROAD TRACK

OIL PIPELINE

NOTE:
ANALYTICAL RESULTS ARE FOR SURFACE SOIL SAMPLES COLLECTED AT 0' TO 1' DEPTH INTERVAL, UNLESS NOTED OTHERWISE.

NO LEAD CONCENTRATIONS EXCEED THE EPA TRW ADULT LEAD MODEL ACTION LEVEL OF 2,725 MG/KG FOR COMMERCIAL DEVELOPMENT

TRW – TECHNICAL REVIEW WORKSHOP

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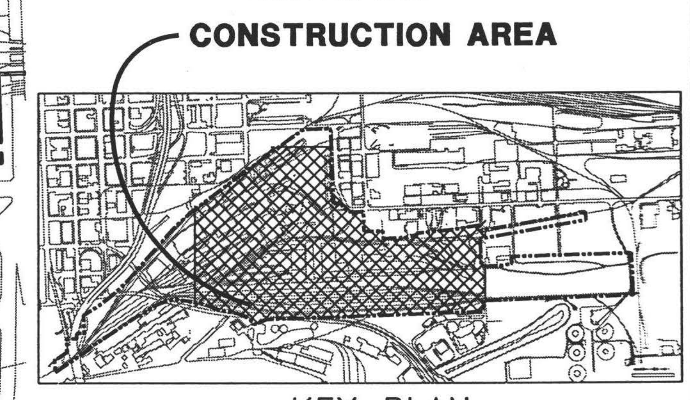

KEY PLAN

LEAD CONCENTRATIONS IN SURFACE SOIL–CONSTRUCTION AREA

UNION PACIFIC

REMEDIAL ACTION PLAN
OMAHA SHOPS
UNION PACIFIC RAILROAD COMPANY

Woodward-Clyde

DRN BY SCR	DATE 05/24/96	PROJECT NO. 91MC204	FIG. NO. 2–5
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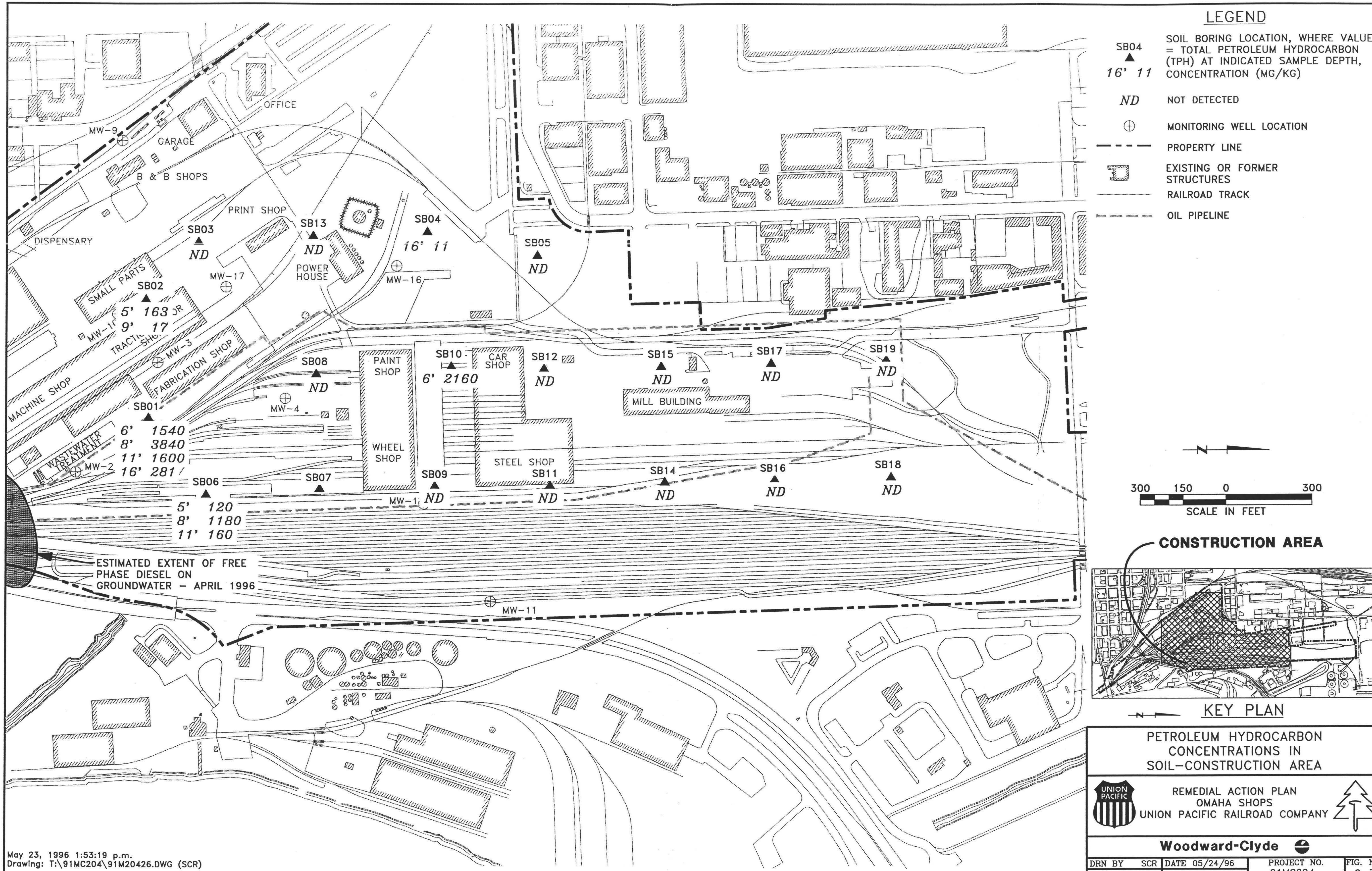

LEGEND

SB04 ▲ 16' 11	SOIL BORING LOCATION, WHERE VALUE = TOTAL PETROLEUM HYDROCARBON (TPH) AT INDICATED SAMPLE DEPTH, CONCENTRATION (MG/KG)
ND	NOT DETECTED
⊕	MONITORING WELL LOCATION
	PROPERTY LINE
	EXISTING OR FORMER STRUCTURES
	RAILROAD TRACK
	OIL PIPELINE

PETROLEUM HYDROCARBON CONCENTRATIONS IN SOIL–CONSTRUCTION AREA

REMEDIAL ACTION PLAN
OMAHA SHOPS
UNION PACIFIC RAILROAD COMPANY

Woodward-Clyde

DRN BY SCR	DATE 05/24/96	PROJECT NO.	FIG. NO.
CHK'D BY JAW	REVISION 0	91MC204	2-7

May 23, 1996 1:53:19 p.m.
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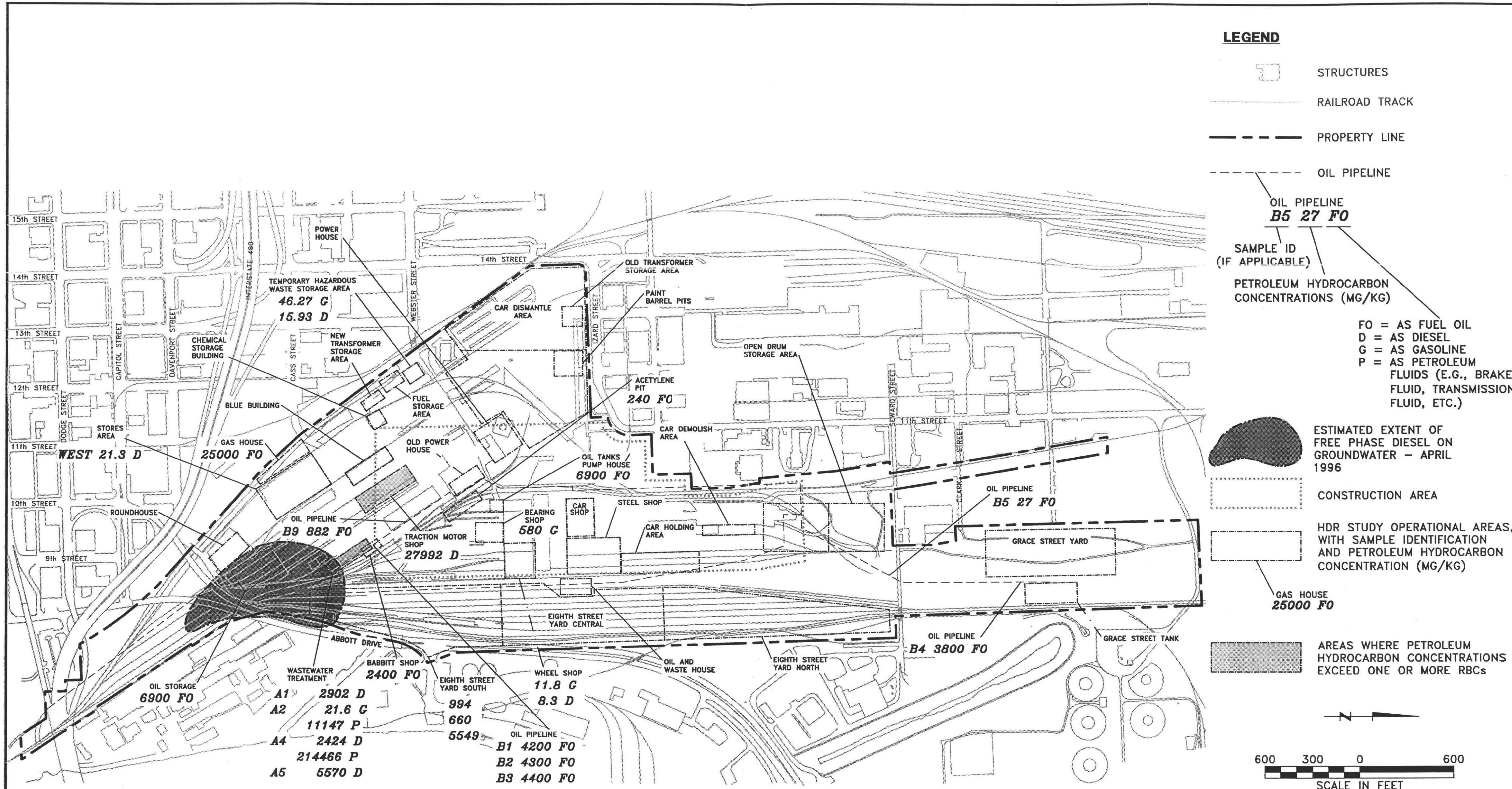


PETROLEUM HYDROCARBON CONCENTRATIONS IN SOIL–OPERATIONAL AREAS

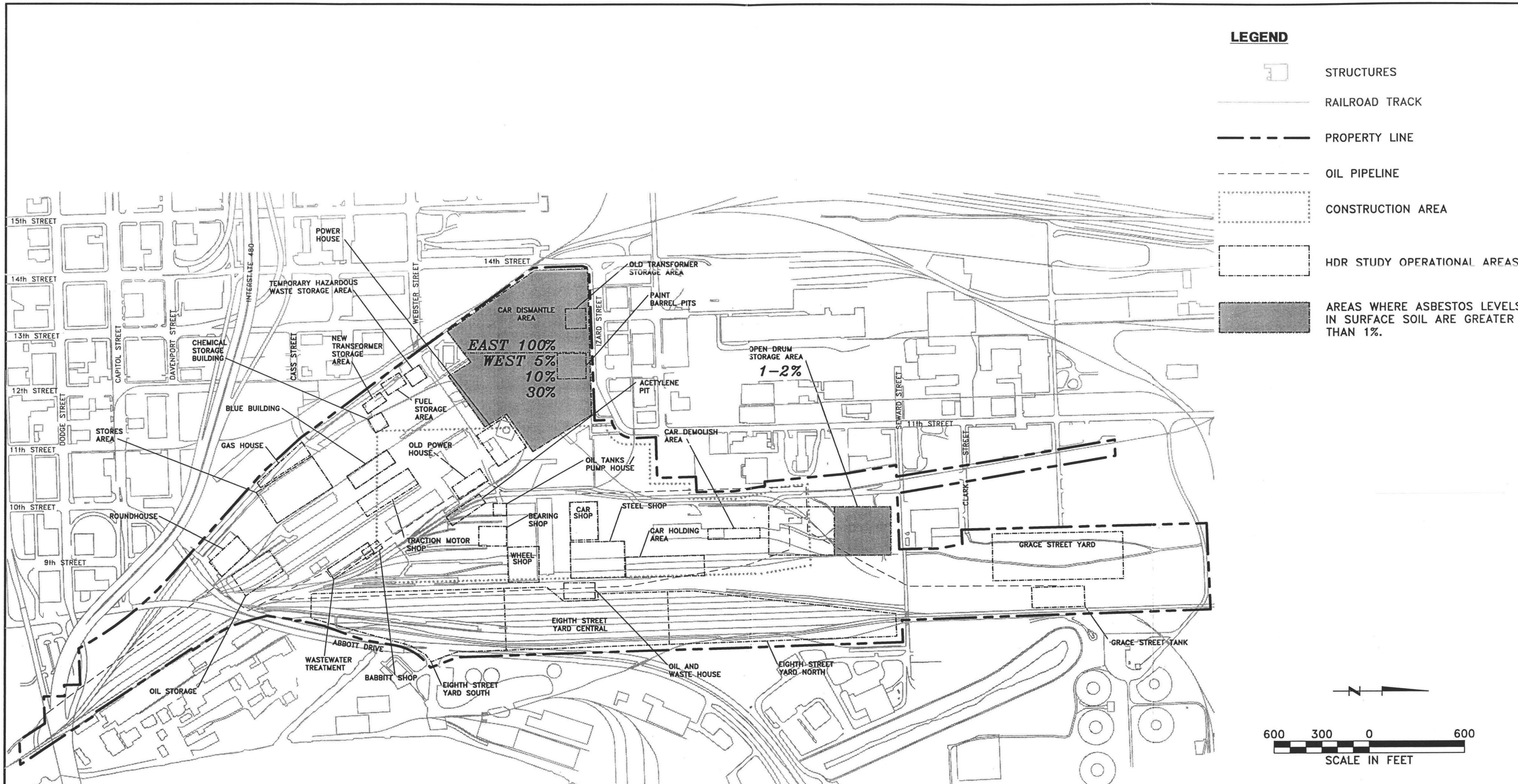
UNION PACIFIC

REMEDIAL ACTION PLAN
OMAHA SHOPS
UNION PACIFIC RAILROAD COMPANY

Woodward-Clyde

DRN BY SCR	DATE 05/24/96	PROJECT NO.	FIG. NO.
CHK'D BY JAW	REVISION 0	91MC204	2–6

August 28, 1996 1:05:21 p.m.
Drawing: T:\91MC204\91M20429.DWG (JWB)
Xrefs: OMAHAYRD.DWG



August 29, 1996 10:13:16 a.m.
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Xrefs: OMAHAYRD.DWG

ASBESTOS LEVELS IN SURFACE SOIL – OPERATIONAL AREAS

UNION PACIFIC

REMEDIAL ACTION PLAN
OMAHA SHOPS
UNION PACIFIC RAILROAD COMPANY

Woodward-Clyde

DRN BY SCR	DATE 08/28/96	PROJECT NO. 91MC204	FIG. NO. 2-8
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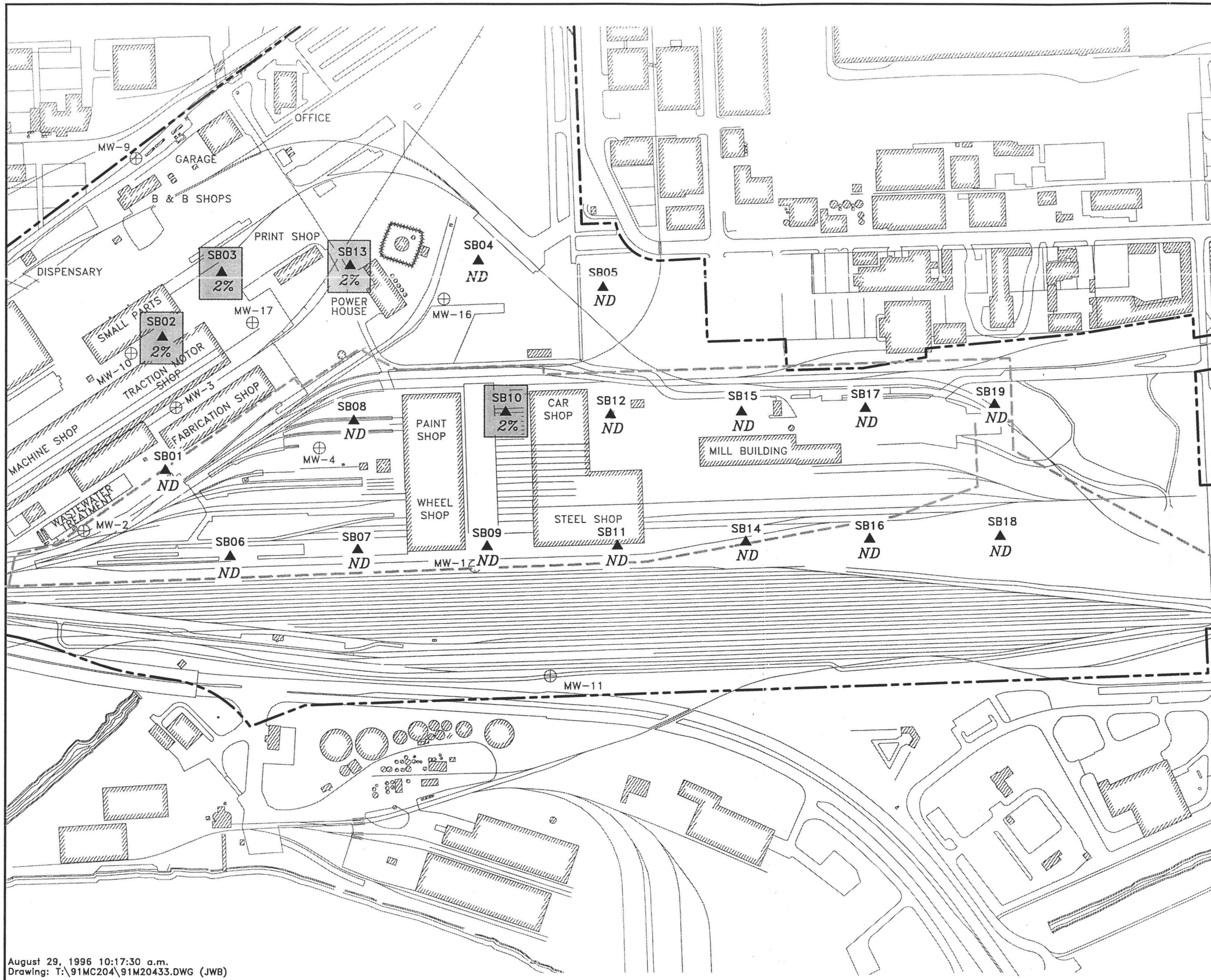

LEGEND

SB03 ▲ 2% — SOIL BORING LOCATION, VALUE = TOTAL ASBESTOS CONCENTRATION

ND — NOT DETECTED

MONITORING WELL LOCATION

PROPERTY LINE

EXISTING OR FORMER STRUCTURES

RAILROAD TRACK

OIL PIPELINE

ASBESTOS LEVELS IN SURFACE SOIL ARE GREATER THAN 1%

NOTE:
ANALYTICAL RESULTS ARE FOR SURFACE SOIL SAMPLES COLLECTED AT 0' TO 1' DEPTH INTERVAL, UNLESS NOTED OTHERWISE.

N

300 150 0 300
SCALE IN FEET

CONSTRUCTION AREA

KEY PLAN

ASBESTOS LEVELS IN SURFACE SOIL–CONSTRUCTION AREA

REMEDIAL ACTION PLAN
OMAHA SHOPS
UNION PACIFIC RAILROAD COMPANY

UNION PACIFIC

Woodward-Clyde

DRN BY	SCR	DATE 08/28/96	PROJECT NO.	FIG. NO.
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3.0
PROPOSED REMEDIAL ACTION OBJECTIVES

The proposed remedial action objectives focus on the exposure settings for which protection will be provided. Exposure settings take into consideration the contaminated media, chemicals of concern, and exposure pathways. Consideration of exposure pathways is important, since protection may be achieved by reducing the likelihood of exposure and by reducing contamination levels. Remedial action objectives provide long-term targets to use during development, evaluation, and selection of remedial action alternatives. Risk-based remedial action objectives were developed by identifying and defining media of concern, chemicals of concern, present and future land use, exposure pathways, and target risk levels.

3.1 MEDIA OF CONCERN

EPA's Risk Assessment Guidance for Superfund (EPA 1991b) states that it is generally appropriate to evaluate contaminants in those media where the cumulative current or future excess cancer risk is greater than 1×10^{-4} or the hazard index (HI) is greater than one. A site-specific decision regarding further remedial action should be made when the cumulative current or future excess cancer risk for a medium falls within the range of 1×10^{-6} to 1×10^{-4}.

NDEQ regulations, Title 118 - Ground Water Quality Standards and Use Classification establish numerical standards (maximum contaminant levels) for many of the contaminants found in groundwater at the Omaha Shops site. Title 118 maximum contaminant levels (MCLs) are generally consistent with MCLs established by EPA in the National Primary Drinking Water Regulations (40 CFR Part 141) and the National Secondary Drinking Water Regulations (40 CFR Part 143). Title 118 gives the NDEQ the authority to define a remedial action classification (RAC) for groundwater based upon information obtained in the investigative assessment. The RAC designation determines the level of remediation required for groundwater and is assigned by the NDEQ on a case by case basis.

The NDEQ has determined that the groundwater at the Omaha Shops site is a RAC-3. The RAC-3 determination was made under NDEQ Stipulated Order Number 1468. As a RAC-3 designated site, remediation requirements consist of recovering readily removable contaminants (free product) with associated groundwater monitoring. Therefore, no action levels are proposed, nor will the groundwater be remediated in anticipation of site development. The oil recovery system installed as part of the Stipulated Order to recover free phase diesel will continue to operate until free product recovery is complete.

The results of previous investigations and the screening level risk assessment indicate that soil in some areas of the Omaha shops poses a potential excess cancer risk greater than 1×10^{-6} or a potential noncarcinogenic HI in excess of one. Therefore, soil is the only media of concern to be considered at the Omaha Shops.

3.2 CHEMICALS OF CONCERN

EPA guidance (EPA 1991b) recommends that a chemical in a medium that has an associated risk (i.e., current or future excess cancer risk greater than 1×10^{-6} or HI greater than one) should be retained as a chemical of potential concern for that medium. Likewise, chemicals with associated cancer risks of less than 1×10^{-6} or HI less than one should not be retained as chemicals of concern unless there are significant concerns about multiple contaminants and pathways.

The results of the screening level risk assessment for the Omaha Shops indicate that the following chemicals pose a potential excess cancer risk greater than 1×10^{-6} or HI greater than one:

Metals:	Arsenic
	Chromium
	Lead
Volatile Organic Compounds:	Tetrachloroethene
	Trichloroethene
Semivolatile Organic Compounds:	Benzo(a)anthracene
	Benzo(a)pyrene
Pesticides/PCBs:	Aldrin
	Dieldrin
	Heptachlor Epoxide

	Aroclor 1016
	Aroclor 1221
	Aroclor 1232
Petroleum Hydrocarbons:	TPH as Brake, Hydraulic, or Transmission fluid
	TPH as No. 2 Diesel
Asbestos	

As discussed in Section 2, many of the chemicals of concern are present at levels within EPA's target risk range of 1×10^{-6} to 1×10^{-4}. Chromium, trichloroethene, the SVOCs, and pesticides/PCBs are eliminated as chemicals of concern because they exceed the calculated RBCs by less than a factor of 10 (excess cancer risk less than 1×10^{-5}). Tetrachloroethene is eliminated as a chemical of concern because the high concentration detected in a single sample could not be confirmed in subsequent investigations. Therefore, the chemicals of concern at the Omaha Shops (see Figure 3-1) are:

- Arsenic
- Lead
- Petroleum hydrocarbons
- Asbestos

3.3 PRESENT AND FUTURE LAND USE AND GROUNDWATER USE

The Omaha Shops site is located in an area that is predominantly industrial in nature, with a few commercial and civic areas. Currently, groundwater beneath the site is not used as a drinking water supply. The Douglas County Health Department's current policy is to not allow any new drinking water supply wells within the Metropolitan Utilities District service area. Special use industrial wells (e.g., closed systems, heat pumps, etc.) may be allowed on a case by case basis. Therefore, domestic and industrial groundwater use is not expected to occur in the future.

Future land use at the Omaha Shops and the surrounding area is expected to remain industrial and commercial indefinitely. Residential development in this area is not likely, given the existing surrounding land use; however, multi-family residential development of portions of the property has been included in some of the commercial development proposals for the property. If residential development of the property were to occur, it would likely be multi-family, professionally managed units within a limited area of the property.

3.4 EXPOSURE PATHWAYS

The exposure pathways at the Omaha Shops that were considered in developing risk-based action levels for soil and groundwater include the following:

- **Soil:** Potential future receptors to site-related chemicals in soil are recreational users, occupational workers, and construction workers. The routes by which they may be exposed and which were considered in developing risk-based action levels for soil are:

  - Ingestion of soil

  - Inhalation of volatile chemicals and chemicals bound to airborne particulates emitted from soil

  - Dermal contact with soil

- **Groundwater:** Construction workers are the only potential future receptors to site-related chemicals in groundwater at the Omaha Shops. The routes by which they may be exposed and which were considered in developing risk-based action levels for groundwater are:

  - Ingestion of water
  - Inhalation of volatile chemicals from groundwater
  - Dermal contact with groundwater

3.5 TARGET RISK LEVELS

For carcinogenic health effects, action levels were developed that correspond to a risk range of 1×10^{-6} to 1×10^{-4} of an individual developing cancer over a lifetime as a result of exposure to the potential carcinogens from all significant exposure pathways for a given medium. A lifetime excess cancer risk range of 1×10^{-6} to 1×10^{-4} is the EPA acceptable risk range that is to be used when making remedial action selection decisions under CERCLA (EPA 1991b).

For noncarcinogenic health effects, action levels were developed that correspond to a HI of one. A total HI equal to one indicates that no adverse noncarcinogenic effects are expected to occur to sensitive individuals over a lifetime of exposure. An HI equal to one was used as the target risk for developing action levels for the Omaha Shops.

3.6 ACTION LEVELS

Risk-based action levels represent proposed levels that would reduce estimated potential health risks caused by exposure to soil and groundwater to the following levels:

- Between 1×10^{-6} and 1×10^{-4} for carcinogenic risks
- An HI less than or equal to one for noncarcinogenic risks

The following discussion summarizes proposed risk-based action levels for the chemicals of concern at the Omaha Shops.

3.6.1 Arsenic

No specific regulatory limits have been established for total arsenic concentrations in soil. Using a conservative value of 10 times the occupational RBC (11.3 mg/kg) for arsenic would result in an action level of 113 mg/kg. This value represents a risk value of 1×10^{-5} which is 10 times less than the maximum concentration of arsenic determined using the EPA's target risk range of 1×10^{-6} to 1×10^{-4} for carcinogens. An action level of 113 mg/kg is proposed for arsenic.

3.6.2 Lead

An action level of 2,725 mg/kg lead in soil is proposed for the Omaha Shops assuming a commercial worker scenario for adults, potentially including pregnant women. The proposed action level is a more appropriate estimate of health-protective cleanup levels for adult and fetal exposure to lead in soil than are levels selected from the generic 500 to 1,000 mg/kg range derived by EPA-based on blood lead levels in children.

3.6.3 Petroleum Hydrocarbons

Neither Nebraska nor federal regulations specify acceptable concentrations of petroleum hydrocarbon contamination in soils. The NDEQ evaluates sites on a case by case basis and defines clean soils as having less than detectable petroleum hydrocarbon concentrations. Recent projects in the vicinity of the Omaha Shops have encountered petroleum hydrocarbon soil contamination resulting from leaking underground storage tank systems. An action level of 1,000 mg/kg petroleum hydrocarbons in the soil was used in 1989 at the Omaha Riverfront Development Project. In this case, soil with petroleum hydrocarbon levels exceeding 1,000 mg/kg were excavated and either landfarmed on site or disposed of in a sanitary landfill. Considering the similarities of the geology and land use at the Riverfront Development Project site and the Omaha Shops, it is reasonable to expect that a similar action level would be applied at the Omaha Shops. Therefore, 1,000 mg/kg is proposed as the action level for petroleum hydrocarbons in soil.

Legislative Bill (LB) 1266, passed by the Nebraska Legislature and signed into law in April 1996, directs the NDEQ "to consider the risk to human health and safety and to the environment in evaluating and approving plans for remedial action". Furthermore, LB 1226 requires that, for petroleum releases, "the plan for remedial action shall take into account risk-based corrective action assessment principles which identify the risks presented to the public health and safety or the environment by each release in a manner that will protect the public health and safety and the environment using, to the extent appropriate, a tiered approach consistent with the American Society for Testing and Materials standards".

In response to this legislative directive, the NDEQ is developing guidance for applying risk assessment methodologies to determine appropriate corrective actions for petroleum hydrocarbon releases. This guidance, when it becomes available, will be applied to the Omaha Shops site to establish a risk-based action level for petroleum hydrocarbons in soil. The currently proposed action level of 1,000 mg/kg will be revised if the NDEQ risk-based guidance is published prior to initiating remedial action at the Omaha Shops.

3.6.4 Asbestos

The asbestos standard (OSHA 1926.1101) defines asbestos-containing material (ACM) as any material containing more than one percent asbestos. The action level for asbestos in soil at the Omaha Shops is one percent.

3.7 REMEDIAL ACTION OBJECTIVES

The proposed remedial action objectives focus on the exposure settings for which protection will be provided. Exposure settings take into consideration the chemicals of concern, contaminated media, and exposure pathways. The consideration of exposure pathways is important, since protection may be achieved by reducing the likelihood of exposure and by reducing contamination levels.

Four exposure settings were identified as posing potential health risks at the Omaha Shops. These exposure settings include the following:

- Recreational user, occupational user, and construction worker exposure settings involving direct contact with, inhalation of, and ingestion of contaminated soil

- Direct contact with, inhalation of, and ingestion of contaminated groundwater by construction workers

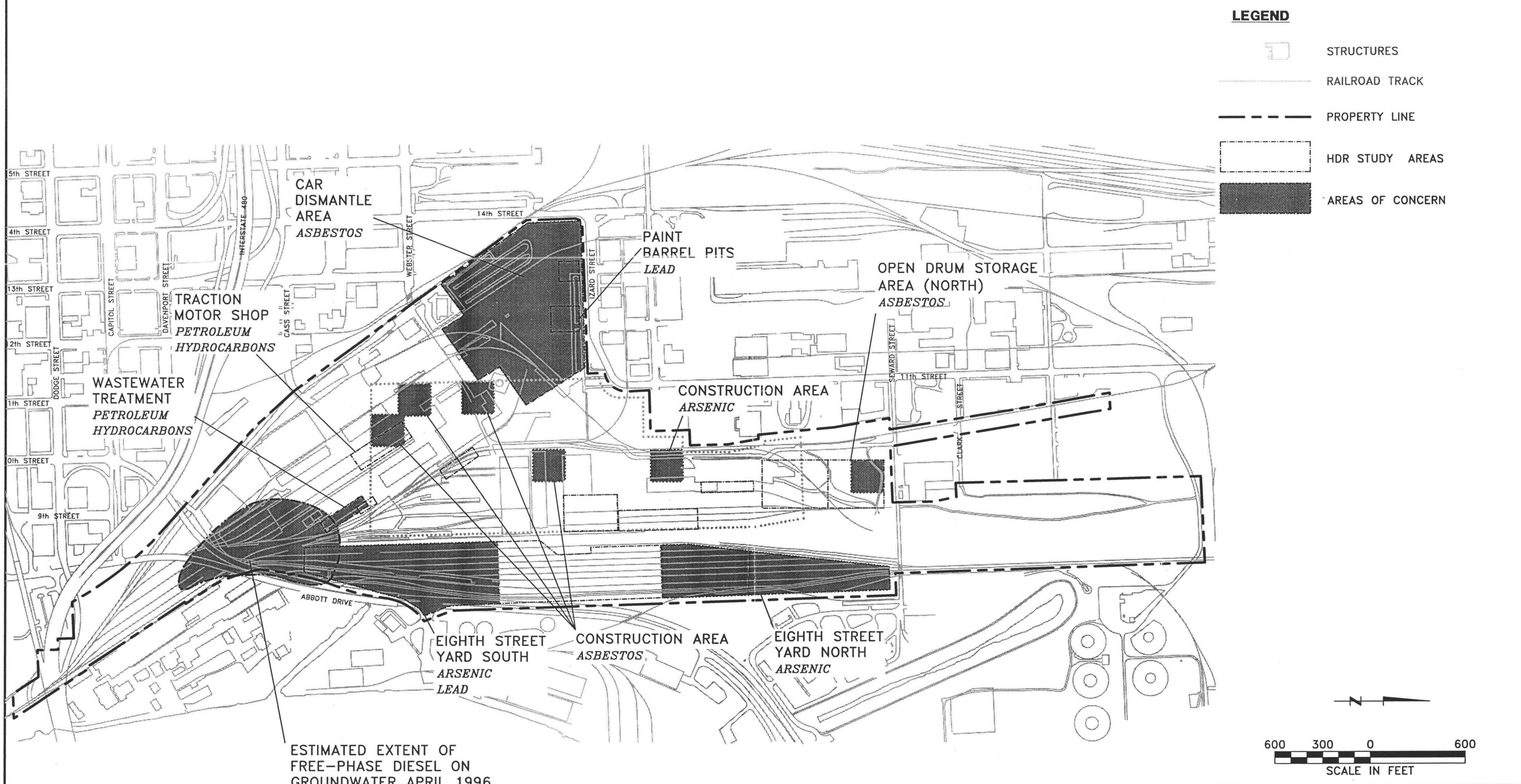
The chemicals of concern are arsenic, lead, petroleum hydrocarbons, and asbestos.

Three site remedial objectives are proposed for the Omaha Shops based on existing knowledge of the site and potential risks posed by the site:

- Reduce the probability and degree of exposures to chemicals of concern in the soil and groundwater to levels that are considered protective of human health and the environment.

- Contain free phase diesel in groundwater using the existing fuel recovery system and prevent migration of free phase diesel into future below ground structures.

- Reduce the levels of contaminants from construction dewatering activities to levels that will allow discharge to the City of Omaha sanitary sewer system.



POTENTIAL AREAS OF CONCERN

REMEDIAL ACTION PLAN
OMAHA SHOPS
UNION PACIFIC RAILROAD COMPANY

Woodward-Clyde

DRN BY SCR	DATE 05/24/96	PROJECT NO.	FIG. NO.
CHK'D BY JAW	REVISION 0	91MC204	3-1

August 29, 1996 9:25:03 a.m.
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Xrefs: OMAHAYRD.DWG

4.0
DESCRIPTION OF THE PROPOSED ACTION

4.1 CONSTRUCTION ACTIVITIES

Construction activities for commercial development at the Omaha Shops are presently undefined. The proposed actions described in this plan have been developed to address the issues reasonably expected to be involved in any commercial development at the Omaha Shops. While the specific details of site development are not available at this time, the activities addressed in this plan are intended to be generic in nature and would apply to any commercial development proposal for the Omaha Shops. The following proposed actions would be undertaken during commercial development construction activities.

4.2 EXCAVATED SOIL MANAGEMENT

The remedial action objectives described in Section 3.7 focused on four exposure settings. The following three exposure settings involved direct contact with, inhalation of, and ingestion of contaminated soil:

- Recreational users
- Occupational users
- Construction workers

This section describes actions to reduce the probability and degree of exposures to chemicals of concern in the soil to levels that are protective of human health and the environment.

4.2.1 Areas of Concern

The following nine areas at the Omaha Shops were identified as "areas of concern" due to the presence of contaminants in soil above action levels (see Figure 3-1):

- Free-Phase Diesel Recovery Area — Petroleum Hydrocarbons
- Wastewater Treatment Area — Petroleum Hydrocarbons

•	Traction Motor Shop	Petroleum Hydrocarbons
•	Car Dismantle Area	Asbestos
•	Paint Barrel Pits	Lead
•	North Open Drum Storage Area	Asbestos
•	Eighth Street Yard South	Arsenic Lead
•	Eighth Street Yard North	Arsenic
•	Construction Area	Arsenic (single sample location) Asbestos (four sample locations)

4.2.2 Excavation and Placement

Soil exceeding the action levels for arsenic (113 mg/kg) or lead (2,725 mg/kg) will be managed in the following manner (Figure 3-1):

- Soil that will not be disturbed by construction will be covered with a minimum of one foot of clean soil. Prior to placement of clean soil, soil samples will be collected and analyzed to document arsenic and lead concentrations in soil to be left in place. Surface completion may consist of pavement or vegetative cover.

- Soil disturbed by construction will be placed in an area of the property designated as a repository for soils containing lead and arsenic above action levels. Following excavation of soils exceeding action levels, soil samples will be collected and analyzed to document arsenic and lead concentrations in the remaining soil. If soil exceeding action levels for arsenic or lead remains, it will be covered with a minimum of one foot of clean soil.

Soil samples will also be collected from the excavated soil to document arsenic and lead concentrations in soil to be placed in the on-site repository. Soil placed in the on-site repository will be covered with a minimum of one foot of clean soil. Surface completion in the on-site repository area may consist of pavement or vegetative cover.

Soil with petroleum hydrocarbon concentrations exceeding the action level (1,000 mg/kg) will be managed in the following manner (Figure 3-1):

- Soil that will not be disturbed by construction will be covered with a minimum of one foot of clean soil. Prior to placement of clean soil, soil samples will be collected and analyzed to document petroleum hydrocarbon concentrations in soil to be left in place. Surface completion may consist of pavement or vegetative cover.

- Soil disturbed by construction will be transported to an area of the property designated as a treatment unit for soil containing petroleum hydrocarbons above action levels. Following excavation of soil exceeding action levels, soil samples will be collected and analyzed to document petroleum hydrocarbon concentrations in the remaining soil. If soil exceeding action levels for petroleum hydrocarbons remain, they will be covered with a minimum of one foot of clean soil.

  Soil samples will also be collected from the excavated soil to document petroleum hydrocarbon concentrations in soil to be placed in the on-site treatment unit. Soil placed in the on-site treatment unit will be treated until the petroleum hydrocarbon concentration is below action levels. Following treatment, the soil may be used as fill in other areas of the site.

- Depending on specific site development plans, passive or active barrier systems may be required to prevent the migration of petroleum hydrocarbon vapors into basements, sewers, or other structures planned for the Omaha Shops. These types of systems will be described in the detailed construction documents for site development.

Soil with asbestos levels exceeding the action level (1 percent) will be managed in the following manner (Figure 3-1):

- Soil in the Open Drum Storage Area will be sampled to confirm the Phase I Site Assessment detection. Sixteen soil samples will be collected from a 50-foot by 50-foot grid for laboratory analysis. If the results of the confirmation sampling analysis exceed the action level, the Open Drum Storage Area will be managed as described below.

- Soil that will not be disturbed by construction will be covered with a minimum of one foot of clean soil. Prior to placement of clean soil, soil samples will be collected and analyzed to document asbestos levels in soil to be left in place. Surface completion may consist of pavement or vegetative cover.

- Soil disturbed by construction will be placed in an area of the property designated as a repository for soil containing asbestos above action levels. Following excavation of soil exceeding action levels, soil samples will be collected and analyzed to document asbestos levels in the remaining soil. If soil exceeding action levels for asbestos remain, they will be covered with a minimum of one foot of clean soil.

  Soil samples will also be collected from the excavated soil to document asbestos levels in soil to be placed in the on-site repository. Soil placed in the on-site repository will be covered with a minimum of one foot of clean soil. Surface completion in the on-site repository area may consist of pavement or vegetative cover.

4.2.3 Fugitive Dust Control

Dust control measures will be employed to minimize the generation and dispersion of dust containing lead, arsenic, and asbestos during construction. The construction documents will require that the contractor use water or other wetting agents to control dust. The construction documents will allow UPRR to suspend construction activities if the contractor fails to maintain effective dust control.

4.2.4 Confirmation Sampling

Soil samples will be collected during construction for the following purposes:

- To document arsenic, lead, petroleum hydrocarbon, or asbestos concentrations in soil to be left in place

- To document arsenic, lead, petroleum hydrocarbon, or asbestos concentrations in soil excavated during construction and placed in on-site repositories or treatment units

Samples to document arsenic, lead, petroleum hydrocarbon, or asbestos concentrations in soil to be left in place will be collected at locations and frequencies depending on the area to be sampled. For large open areas, samples will be collected based on a horizontal sampling grid. The spacing of the horizontal sampling grid will be 100 feet by 100 feet, with one area composite sample to be collected from each grid block. This rationale effectively results in one sample being collected for every 10,000 square feet of area. For linear areas, such as utility corridors, roadways, etc., samples will be collected at approximately the same frequency, i.e., one sample for every 10,000 square feet. Samples to document arsenic, lead, petroleum hydrocarbon, or asbestos concentrations in soil to be placed in on-site repositories or treatment units will be collected at a frequency of one composite sample for every 1,000 cubic yards of soil excavated.

4.3 AIR MONITORING

Air monitoring will be required to demonstrate the effectiveness of contractor dust control efforts. Four high volume air samplers will be installed at the site to collect samples for particulate, total lead, total arsenic, and asbestos analysis. Proposed air monitoring stations are shown on Figure 4-1. The prevailing wind direction for the site during a typical construction season is from the south-southeast. Monitoring station MS-1 is located near the southern boundary of the site and will serve as the background air monitoring station.

Monitoring stations MS-2, MS-3, and MS-4 are located along the northern perimeter of the Omaha Shops and would serve as downwind monitoring stations for the site development construction activities. Monitoring station locations are subject to change and may be adjusted depending on actual site development plans. Background samples will be collected at each monitoring station prior to beginning construction activities.

Air monitoring sampling frequency, equipment, and procedures will be detailed in a Sampling and Analysis Plan (SAP).

4.4 PRE-DESIGN TESTING FOR PAINT BARREL PITS AREA

Additional soil data will be collected at the Paint Barrel Pits to estimate the horizontal and vertical extent of the pits. Two trenches will be excavated in the Paint Barrel Pits and samples will be collected for laboratory analysis. Four additional trenches will be excavated at the ends of the Paint Barrel Pits to estimate the length of the pits by visual observation (see Figure 4-2). Based on the results of these activities, the Paint Barrel Pits may be closed in place and their location deed recorded.

4.4.1 Background

The Paint Barrel Pits were identified during the Phase I Site Assessment. Two formerly used pits are located directly south of the 12th and Izard Streets intersection. Each pit reportedly measures 150 feet long by 21 feet wide (HDR 1990).

Six borings were completed in the Paint Barrel Pits area (HDR 1990). These borings were spaced evenly along the apparent centerline of the former pits, as identified by historical blueprints. A composite soil sample was collected for total metals, EP Toxicity, and SVOC analysis. Wood, asphalt, slag, wire, brass machine parts, asbestos, cinders, sand, gravel, and traces of clay were observed in the borings from 0 to 5 feet. Two borings that were extended to 10 feet encountered a dark gray silty clay at 8 feet. A strong creosote odor was noticed at the four boreholes closest to Izard Street, with OVA readings of 10 to 400 parts per million. Several metals and SVOCs were found in the soil samples (HDR 1990)

4.4.2 Proposed Trenching and Soil Sampling

The trenches will be dug using a backhoe that takes 1-foot-deep passes with the excavating bucket. Trenches will be excavated to a maximum depth of 10 feet, or to the water table, whichever is less. A trench log will be completed describing the soil and materials encountered.

Soil samples will be collected directly out of the backhoe bucket, or by using a tube sampler attached to the backhoe bucket, or a hand auger sampler. Soil samples will be collected at 2-foot depth intervals and field screened for volatile organic vapors. Two samples will be collected from each of the Paint Barrel Pits and submitted for laboratory analysis. One sample in each of the Paint Barrel Pits will be collected from the interval exhibiting the highest field-screened volatile organics level. The second sample from each Paint Barrel Pit will be collected from undisturbed native soil or fill underlying the Paint Barrel Pits. Both samples will be submitted for laboratory analysis of VOCs, SVOCs, pesticides and PCBs, TRPH, and total metals. The samples will also be analyzed for TCLP VOCs, SVOCs, and metals.

Additional soil samples may be submitted for laboratory analysis if highly contaminated zones (as determined visually and by field screening) are encountered. The planned analytical methods, sample containers, minimum sample size, preservation method, and maximum holding times are listed in Table 4-1. The projected number of soil samples, including QC samples, is listed in Table 4-2.

4.4.3 Survey

After determining the horizontal extent of the Paint Barrel Pits, the Paint Barrel Pits will be surveyed. Permanent surveyed benchmarks will be established to identify the location of the Paint Barrel Pits. The survey data will be used, if necessary, to deed restrict the area to prevent future disturbance.

4.5 FUEL RECOVERY SYSTEM

4.5.1 Existing System

The existing fuel recovery system is located under the Abbott Drive viaduct, southeast of the former locomotive fueling and servicing area. The system was installed in 1988 and is designed to recover free-phase diesel fuel from the groundwater surface. A series of 13 recovery wells, fitted with pneumatic pumps, transfers diesel and groundwater to an oil/water separator. The separated diesel is stored until it is periodically retrieved by an oil recycling contractor. Treated groundwater is discharged to the City of Omaha sanitary sewer system. Information and data generated for operation of the fuel recovery system are reported to NDEQ on a quarterly basis (USPCI/Laidlaw 1996).

During the first quarter of 1996, 1,251 gallons of product were recovered by the system, at an average rate of 10.6 gallons per day (gpd) over 118 operating days. A total of 2,517,600 gallons of treated water was discharged to the City of Omaha sanitary sewer at an average rate of 21,376 gpd over 118 operating days.

4.5.2 System Modifications

The fuel recovery system may be modified to enhance recovery operations. Depending on specific site development plans, system modifications may be required to prevent the migration of free-phase diesel into basements, sewers, or other structures planned for the Omaha Shops. System modifications, if required, will be described in the detailed construction documents for site development.

4.6 CONSTRUCTION DEWATERING

Dewatering may be required for construction of basements, sewers, and other subsurface structures below the water table at the Omaha Shops. The main purpose of dewatering will be to enable construction to be carried out under relatively dry conditions.

4.6.1 Dewatering Methods

Dewatering for construction of subsurface structures below the water table will be accomplished using standard construction dewatering methods such as well points or deep wells. The following two dewatering environments are present at the Omaha Shops:

- In the southern and western parts of the Omaha Shops site, the natural soils beneath the surface fill generally consist of thick deposits of highly plastic clay underlain by rock. For dewatering purposes, these conditions are not expected to produce large quantities of water during construction.

- At the eastern and northern end of the site, the natural soils generally consist of a thin discontinuous layer of soft to medium clay underlain by medium dense to dense alluvial sands. For dewatering purposes, these conditions are expected to produce relatively large quantities of water during construction.

Construction dewatering may be required in either of the above conditions. Dewatering methods will be selected based on the specific site development plans. Dewatering requirements will be described in the detailed construction documents for site development.

4.6.2 Testing, Handling, and Disposal of Extracted Groundwater

Groundwater produced from dewatering activities will be discharged to the City of Omaha's sanitary sewer system. Pretreatment may be required prior to discharging groundwater from dewatering activities. If construction dewatering is planned in the area where free-phase diesel is present in the groundwater, pretreatment operations similar to those currently employed for the diesel fuel recovery system at the site will be required. Currently, an oil/water separator is used to separate diesel from the pumped groundwater. The separated diesel is stored until it is periodically retrieved by an oil recycling contractor, and treated groundwater is discharged to the City of Omaha sanitary sewer system.

Groundwater from dewatering activities in other areas of the Omaha Shops site are not expected to require treatment prior to discharge to the sanitary sewer. The human health risk assessment for groundwater (see Appendix) evaluated whether chemicals detected in groundwater at the Omaha Shops could potentially pose an unacceptable risk to human health during construction activities. The risk assessment concluded that elevated levels of petroleum hydrocarbons (No. 2 fuel oil) detected in the groundwater in the sump in the Stores Building was the only location where risk-based action levels were exceeded for construction workers. This location is near the area where free-phase diesel is present in the groundwater.

Details of the pretreatment system for groundwater produced by construction dewatering will depend on the specific site development plans. Groundwater quality will be evaluated as part of the predesign activities for site development and the City of Omaha Public Works Department will be consulted for approval to discharge to the sanitary sewer system. Pretreatment requirements for extracted groundwater will be described in the detailed construction documents for site development.

4.7 DEED RESTRICTIONS/ACCESS CONTROL

Deed restrictions for the Omaha Shops property would restrict or prohibit future land uses, particularly those that would involve intrusive activities. Restricted activities will include construction, infrastructure development, and groundwater supply well development. Although deed restrictions are subject to changes in political jurisdiction, legal interpretation, and regulatory enforcement, they will provide protection against direct contact with contaminants.

Public access to the site will be controlled by UPRR. UPRR personnel will have access to the property, but no direct exposure pathway to contaminants in the soil or groundwater will exist following development of the property. Exposure to contaminants through periodic intrusive activities for utilities construction, landscaping, etc., will be controlled through implementation of a long-term site management plan.

4.8 HEALTH AND SAFETY

4.8.1 Construction Activities Health and Safety Plan

A site specific health and safety plan (HASP) will be developed to govern construction activities at the Omaha Shops. The plan will provide site background information and will describe health and safety procedures and protocols, decontamination procedures, personnel training, and medical surveillance requirements for anticipated on-site activities. The plan will identify expected hazards or problems which may be encountered and will describe how these will be addressed. The HASP will specify action levels for the various hazardous substances expected to be encountered at the site. Procedures for protecting third parties, such as visitors and noncontractor employees, will also be included. The HASP will also address applicable UPRR safety requirements for contractors.

Occupational Safety and Health Administration (OSHA) Standards for activities at hazardous waste sites (29 CFR 1910.120) are not expected to be applicable to general construction activities at the Omaha Shops site; however, some activities will require special provisions to protect worker health and safety. These activities include the following:

- Earthwork which includes handling materials containing lead, arsenic, petroleum hydrocarbons, or asbestos

- Dewatering activities in areas with free phase diesel fuel in groundwater

Each of these activities will be described in detail in the construction activities HASP. Issues related to these activities are discussed in this section.

4.8.2 Lead Standard

The lead standard (OSHA 1926.62) applies to "all construction work where an employee may be occupationally exposed to lead." Construction work is defined as work for construction, alteration and/or repair, including demolition or salvage of structures where lead or materials containing lead are present. Due to the presence of lead in the soil at the Omaha Shops, it is reasonable to expect that construction workers could be exposed to fugitive dust containing lead. Based on the potential for construction workers' exposure to materials containing lead, the lead standard will apply to the Omaha Shops site.

The regulations [1926.62(c)] require that the employer assure that no employee is exposed to lead at concentrations greater than the permissible exposure limit (PEL) of 50 micrograms of lead per cubic meter of air (50 $\mu g/m^3$) averaged over an 8-hour period. Specific actions to be taken by the employer to provide this assurance, including exposure assessment and employee protection, are described in the regulations.

An exposure assessment [1926.62(d)(1)] will be completed during the initial phases of site development to determine if any employee may be exposed to lead at or above the action level, which is 30 $\mu g/m^3$ calculated as an 8-hour time-weighted average. This initial determination will be completed by collecting personal samples representative of a full shift, including at least one sample for each job classification in each work area.

Construction workers will be protected during the initial exposure assessment as provided for in OSHA 1926.62(d)(2). Until the initial exposure assessment is completed and it has been documented that construction workers are not exposed above the PEL of 50 $\mu g/m^3$, the construction workers will be treated as if they were exposed above the PEL and worker protective measures will be employed. Applicable worker protective measures will include the following [1926.62(d)(2)(v)]:

- Appropriate respiratory protection
- Appropriate personal protective clothing and equipment
- Change areas
- Hand washing facilities
- Training

If the initial determination shows the possibility of any exposure level at or above the action level (30 $\mu g/m^3$), the contractor will be required to conduct monitoring which is representative of the exposure for each employee in the workplace who is exposed to lead [1926.62(d)(4)]. Specific monitoring requirements are outlined in 1926.62(d)(6). Appropriate respiratory protection or engineering controls and accompanying compliance methods must also be implemented as described in 1926.62(e) if exposures exceed the PEL.

If the initial determination shows that no employee is exposed above the action level, a written record of the determination will be made, including the specific information described in the regulations [1926.62(d)(5)]. Further exposure determination will not be repeated unless there is a change of equipment, process, control, personnel, or a new task is initiated that may result in additional lead exposures above the PEL [1926.62(d)(7)].

The site development earthwork contract documents will include provisions for contractor compliance with lead standard requirements, including an initial exposure assessment. Initial exposure assessment procedures and other lead standard requirements will be detailed in the construction activities HASP.

4.8.3 Asbestos Standard

The asbestos standard (OSHA 1926.1101) applies to construction work where employees have the potential to be exposed to asbestos. Due to the presence of asbestos in the soil at the Omaha Shops, it is reasonable to expect that construction workers could be exposed to asbestos fibers. Based on the potential for construction workers' exposure to asbestos, the asbestos standard will apply to the Omaha Shops site [1926.1101(a)(5) and 1926.1101(a)(6)].

The construction activities anticipated at the Omaha Shops would be defined as Class IV asbestos work [1926.1101(b)]. The regulations require that workers performing Class IV operations receive training equivalent in curriculum and training method to the awareness training course developed by EPA for maintenance and custodial workers who work in buildings containing asbestos-containing material [1926.1101(k)(8)(v)]. Employers are required to assure that no employee is exposed to airborne concentrations of asbestos over the PEL of 0.2 fiber per cubic centimeter (f/cc) of air as an 8-hour time-weighted average (TWA) and the excursion limit of 1.0 f/cc of air as averaged over a sampling period of 30 minutes [1926.1101(c)(2)].

An exposure assessment will be completed during the initial phases of site development to determine if any workers may be exposed to asbestos at or above the action level, which is 0.1 f/cc as an 8-hour TWA. This initial determination will be completed by collecting representative personal samples. Construction workers will be protected during the initial exposure assessment. Until the initial exposure assessment is completed and it has been documented that construction workers are not exposed above the PEL, the construction workers will be treated as if they were exposed above the PEL and worker protective measures will be employed. Applicable worker protective measures will include the following:

- Appropriate respiratory protection
- Appropriate personal protective clothing and equipment
- Change areas
- Hand washing facilities
- Training

If the initial determination shows the possibility of any exposure level at or above the action level, the contractor will be required to conduct activities as required for regulated areas. For this work, a regulated area is an area where operations cause airborne concentrations of asbestos to exceed the PEL, or there is a reasonable possibility that operations may cause airborne concentrations to exceed the PEL [1926.1101(e)(1)].

If the initial determination shows that no workers are exposed above the action level, a written record of the determination will be made. Further exposure determination will not be repeated unless there is a change of equipment, process, control, personnel, or a new task is initiated that may result in additional asbestos exposures above the PEL.

The site development earthwork contract documents will include provisions for contractor compliance with asbestos standard requirements, including an initial exposure assessment. Initial exposure assessment procedures and other asbestos standard requirements will be detailed in the construction activities HASP.

4.9 SAMPLING AND ANALYSIS PLAN

A Sampling and Analysis Plan (SAP) will be prepared as part of the Construction Quality Assurance Plan (CQAP) to provide specific details regarding data collection activities to support implementation of this remedial action plan. Activities to be addressed in the plan will include soil sampling, water sampling, and air sampling. The SAP will describe rationale for selecting sampling methods and techniques. The SAP will also detail sampling objectives; necessary equipment; sample types, location, and frequency; and analyses of interest. The SAP will include a quality assurance discussion that addresses the following elements:

- Quality assurance objectives for data, such as the required precision and accuracy, data completeness, representativeness of data, comparability of data, and the intended use of collected data
- Sample custody procedures
- Specific procedures to assess data precision, representativeness, comparability, accuracy, and completeness
- Data documentation and tracking procedures
- Standard Operating Procedures (SOPs) for field sampling activities

4.10 CONSTRUCTION QUALITY ASSURANCE

UPRR will observe and document contractor activities for implementation of this remedial action plan. A detailed construction quality assurance plan (CQAP) will be developed as part of the site development plan. The CQAP will address the following construction phase issues:

- Communication
- Surveying
- Documentation
- Reporting
- Sampling and Analysis Plan

TABLE 4-1

SAMPLE CONTAINERS, PRESERVATION, AND HOLDING TIMES FOR PAINT BARREL PITS SOIL SAMPLES

Method	Parameter	Containers Per Sample	Minimum Sample Size	Preservation	Holding Time
8240	Volatile organics	Two 4-oz VOA vials with Teflon-lined septa	10 g	4°C	14 days
8270	Semivolatile organics	One 16-oz widemouth glass jar with Teflon-lined lid[1]	30 g	4°C	Extract-14 days Analyze-40 days
8080	Pesticides/PCBs	One 16-oz widemouth glass jar with Teflon-lined lid[1]	30 g	4°C	Extract-14 days Analyze-40 days
418.1	Petroleum hydrocarbons	One 16-oz widemouth glass jar with Teflon-lined lid[1]	30 g	4°C	28 days
6010	Total metals[2]	One 16-oz widemouth glass jar with Teflon-lined lid[1]	10 g	4°C	6 months 28 days Hg

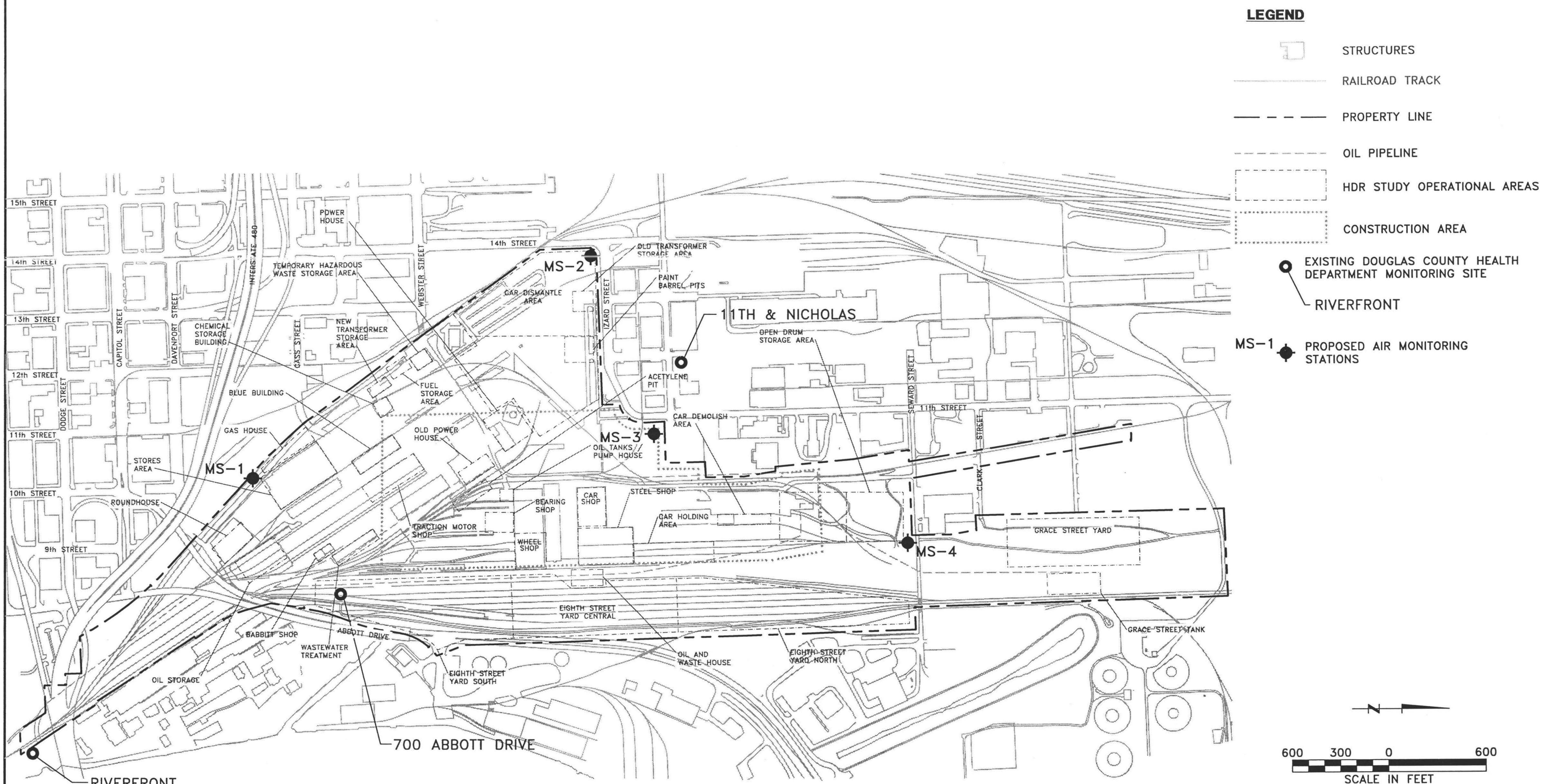
1 One 16-oz glass jar filled with soil is sufficient for all the listed parameters except volatile organics.
2 Total metals include the analysis of TAL metals. In addition to Method 6010, includes 7060 (arsenic), 7740 (selenium), and 7470 (mercury).

TABLE 4-2

PROJECTED PAINT BARREL PITS SOIL SAMPLING BREAKDOWN

Method	Parameter	Quality Control					
		No. of Field Samples	No. of Field Replicates	No. of Trip Blanks	No. of Field Blanks[1]	No. of MS/MSD Samples[2]	Total No. of W-C Samples
8240	Volatile organics	4[3]	0	NA	NA	0/0	4
8270	Semivolatile organics	4[3]	0	NA	NA	0/0	4
8080	Pesticides/PCBs	4[3]	0	NA	NA	0/0	4
418.1	Petroleum hydrocarbons	4[3]	0	NA	NA	NA	4
6010	Total metals[4]	4[3]	0	NA	NA	0/NA	4
1311	TCLP metals, volatile organics, semivolatile organics	4[5]	NA	NA	NA	NA	4

1 Field blanks may consist of equipment rinsates, ambient condition blanks, or water sources.
2 MS = matrix spike; MSD = matrix spike duplicate.
3 Two samples collected in each paint barrel pit.
4 Total metals include the analysis of TAL metals. In addition to Method 6010, includes 7060 (arsenic), 7740 (selenium), and 7470 (mercury).
5 Two samples from each paint barrel pit.
NA = Not applicable



PROPOSED AIR MONITORING STATIONS

REMEDIAL ACTION PLAN
OMAHA SHOPS
UNION PACIFIC RAILROAD COMPANY

Woodward-Clyde

DRN BY SCR	DATE 05/24/96	PROJECT NO.	FIG. NO.
CHK'D BY JAW	REVISION 0	91MC204	4-1

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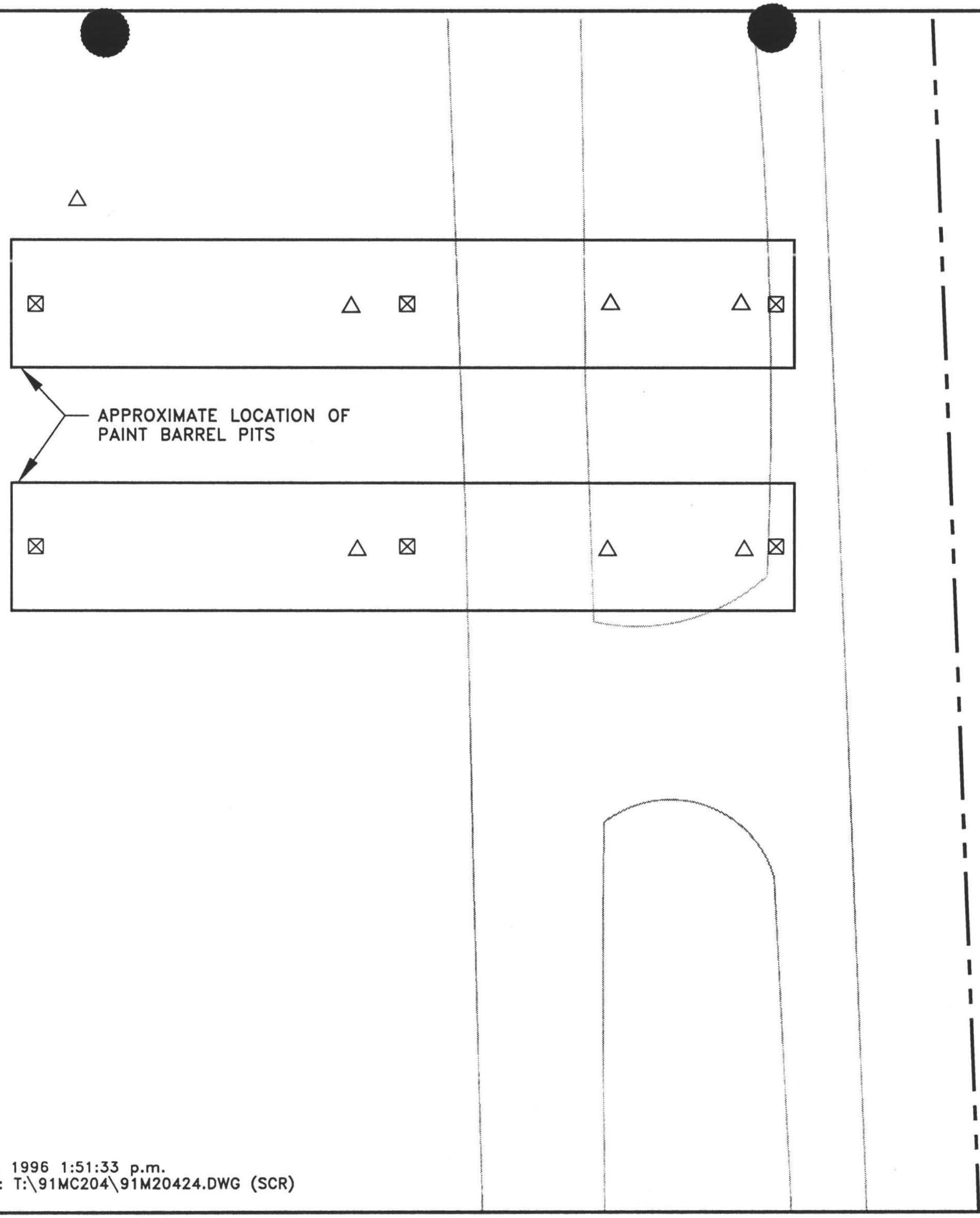


LEGEND

△ APPROXIMATE LOCATION OF PREVIOUS SOIL BORING

⊠ PLANNED TRENCH SOIL SAMPLE

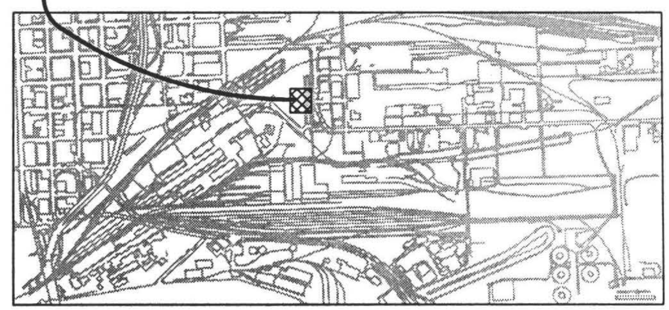
— - - — PROPERTY LINE

N

30 15 0 30

SCALE IN FEET

PAINT BARREL PITS AREA



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KEY PLAN

PAINT BARREL PITS SITE PLAN

UNION PACIFIC

REMEDIAL ACTION PLAN
OMAHA SHOPS
UNION PACIFIC RAILROAD COMPANY

Woodward-Clyde

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5.0
EVALUATION OF THE PROPOSED ACTION

The activities described in this plan are focused on the following three remedial objectives for development of the Omaha Shops property:

- **Protect Human Health and the Environment:** Reduce the probability and degree of exposure to chemicals of concern in the soil and groundwater to levels that are considered protective of human health and the environment.

- **Prevent Migration of Free-Phase Diesel:** Contain free-phase diesel in groundwater using the existing fuel recovery system and prevent migration of free-phase diesel into future below ground structures.

- **Dewatering Discharge to City of Omaha:** Reduce the levels of contaminants in groundwater produced during construction dewatering activities to levels that allow discharge to the City of Omaha sanitary sewer system.

Each of these objectives will be met through the following actions:

- **Protect Human Health and the Environment:** Soil and groundwater management activities are proposed to reduce exposures to chemicals of concern. Soil with arsenic, lead, petroleum hydrocarbons, or asbestos concentrations exceeding action levels will be managed on-site by covering with clean soil to prevent future recreational user and occupational user exposure. Potential lead and asbestos exposures to construction workers will be evaluated using site-specific data during the early phases of construction. Appropriate action will be taken, if necessary, to protect construction workers exposed to lead and asbestos.

  With the exception of a single high detection of #2 fuel oil at the sump in the basement of the Stores Building, construction worker exposure to groundwater at the Omaha Shops is not of concern. The Stores Building has been removed and no longer provides a direct exposure route to the groundwater in the sump. Potential adverse health effects across the site due to incidental ingestion of groundwater by construction workers are, therefore, not considered to be significant.

- **Prevent Migration of Free-Phase Diesel:** The existing fuel recovery system will be modified or expanded to prevent migration of free-phase diesel into below ground structures planned for the Omaha Shops.

- **Dewatering Discharge to City of Omaha:** Groundwater from dewatering activities will be treated, if necessary, prior to discharge to the City of Omaha sanitary sewer system. Groundwater quality will be evaluated and the City of Omaha Public Works Department will be consulted for approval to discharge to the sanitary sewer system.

6.0
PRELIMINARY DESIGN ANALYSIS

This section provides preliminary design information for remedial action associated with development of the Omaha Shops property. The information presented is general in nature, given the lack of detail available regarding specific development plans for the Omaha Shops. A conceptual design document, including basis of design for remedial activities, will be prepared as part of the conceptual design documents for site development.

6.1 SITE PLANNING

The following areas will be shown on the design drawings for site development:

- Areas of concern
- Existing free-phase diesel recovery system
- Proposed free-phase diesel recovery system modifications
- Areas to be excavated
- On-site repositories for soil containing arsenic, lead, and asbestos
- Treatment unit for soil containing petroleum hydrocarbons

6.2 PERMITS/REGULATORY COORDINATION

Permit requirements for development of the Omaha Shops encompass treated water discharge, air emissions, and erosion control and storm water management. Copies of applicable permits will be on site during construction.

6.2.1 Dewatering Discharge

Groundwater from dewatering activities will be discharged to the City of Omaha sanitary sewer system. The City of Omaha Public Works Department will be consulted for approval to discharge to the sanitary sewer system. Dewatering discharge pretreatment requirements will be described in the detailed construction documents for site development. The City of Omaha will prescribe reporting and recordkeeping requirements.

6.2.2 Air Emissions

An air construction permit will not be required for remedial action associated with site development activities. Air monitoring is proposed, however, to demonstrate the effectiveness of contractor dust control efforts. Air monitoring sampling frequency, equipment, procedures, recordkeeping, and reporting will be detailed in the SAP.

6.2.3 Erosion Control and Storm Water Management

Any construction site that will disturb greater than 5 acres (approximately 220,000 square feet) of the site over the life of the project is required to prepare a construction site erosion control and site management plan. This project is expected to disturb more than 5 acres; therefore a construction site erosion control and storm water management plan will be required.

6.3 CIVIL ENGINEERING DESIGN

Civil engineering design required for remedial activities associated with development of the Omaha Shops may include the following elements:

- Site layout
- Geotechnical engineering
- Dewatering
- Excavation, trenching, and backfill
- Grading plans
- Erosion control
- Storm drainage
- Fencing

A conceptual design document, including basis of design for remedial activities, will be prepared as part of the conceptual design documents for site development.

6.4 STRUCTURAL ENGINEERING

Structural engineering required for remedial activities associated with development of the Omaha Shops may include the following elements:

- Foundations for treatment systems
- Structural design for below ground and above ground piping systems
- Structures associated with treatment system modifications

A conceptual design document, including basis of design for remedial activities, will be prepared as part of the conceptual design documents for site development.

6.5 PROCESS AND MECHANICAL ENGINEERING

Process and mechanical engineering required for remedial activities associated with development of the Omaha Shops may include the following elements:

- Groundwater recovery well design for existing treatment system modifications and dewatering activities
- Piping associated with existing treatment system modifications
- Process equipment and pumps for existing treatment system modifications and treatment of groundwater from dewatering activities

A conceptual design document, including basis of design for remedial activities, will be prepared as part of the conceptual design documents for site development.

6.6 ELECTRICAL ENGINEERING

Electrical engineering required for remedial activities associated with development of the Omaha Shops may include the following elements:

- Electrical distribution for existing treatment system modifications and dewatering activities

- Instrumentation and controls for existing treatment system modifications and treatment of groundwater from dewatering activities

- Electrical distribution for air monitoring equipment during construction

A conceptual design document, including basis of design for remedial activities, will be prepared as part of the conceptual design documents for site development.

6.7 PRELIMINARY LIST OF DRAWINGS AND SPECIFICATIONS

A preliminary list of drawings and specifications for remedial activities will be included in the conceptual design documents for site development.

7.0
OPERATION AND MAINTENANCE

Operation and maintenance plans will be prepared for remedial action associated with development of the Omaha Shops. The plans will address two primary elements:

- Operation and maintenance of active remediation systems (e.g., groundwater recovery and treatment systems and soil treatment system)

- Long-term management of soil with arsenic, lead, petroleum hydrocarbon, or asbestos concentrations exceeding action levels

7.1 OPERATIONS MANUAL

An operations manual will be prepared for active remediation systems, such as the groundwater recovery and treatment system and the soil treatment system for petroleum hydrocarbon-contaminated soil. The existing operations manual for the groundwater recovery and treatment system will be modified to incorporate any changes resulting from system modifications. This manual will include system descriptions, start-up procedures, normal operation, emergency procedures, scheduled and unscheduled maintenance, and recordkeeping requirements. The manual will discuss operation and maintenance activities such as groundwater monitoring, influent and effluent sampling and analysis, and periodic inspections.

The soil treatment unit operations manual will address normal operation, emergency procedures, scheduled and unscheduled maintenance, monitoring, and recordkeeping procedures. Both manuals will include support documents such as an equipment list, submittal information, and as-built drawings.

7.2 LONG-TERM MAINTENANCE PLAN

A long-term maintenance plan will be developed to ensure that soils containing arsenic, lead, petroleum hydrocarbon, and asbestos concentrations exceeding action levels continue to be managed as described in this plan. The long-term maintenance plan will address administrative issues, inspection, maintenance, repair, and monitoring. A preliminary outline for the long-term maintenance plan is included in Table 7-1.

TABLE 7-1

PRELIMINARY OUTLINE
LONG-TERM MAINTENANCE PLAN
UPRR OMAHA SHOPS

1.0 INTRODUCTION

- 1.1 PURPOSE
- 1.2 AUTHORITY
- 1.3 CRITERIA

2.0 GENERAL SITE INFORMATION

- 2.1 PREVIOUS INVESTIGATIONS AND REPORTS
- 2.2 REMEDIAL ACTION DESCRIPTION
- 2.3 SITE DEVELOPMENT

3.0 ADMINISTRATION

- 3.1 RESPONSIBILITY
- 3.2 OPERATING RECORDS
- 3.3 SITE SECURITY
- 3.4 UTILITIES, DIGGING PERMITS, AND CLEARANCES

4.0 INSPECTION, MAINTENANCE, AND REPAIR

- 4.1 INSPECTION
- 4.2 MAINTENANCE AND REPAIR
- 4.3 REPORTING

8.0
PROPOSED SCHEDULE

The schedule for development of the Omaha Shops property is currently unknown. A detailed project schedule, including remedial action activities, will be prepared as part of the detailed site development plan. The following key activities will be included in the site development schedule:

- Final Remedial Action Plan
- Construction Quality Assurance Plan
- Sampling and Analysis Plan
- Paint Barrel Pits Investigation
- Construction Activities Health and Safety Plan
- Remedial Action Design (Conceptual, Draft, and Final)
  - Soil Excavation and Management
  - Fuel Recovery System
  - Construction Dewatering
- Remedial Action Construction Activities
- Permitting/Regulatory Coordination
- Deed Restrictions/Access Control
- Operation and Maintenance Plans
- Remedial Action Final Report

9.0 REFERENCES

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APPENDIX A

TECHNICAL REVIEW WORKGROUP ADULT LEAD MODEL FOR COMMERCIAL WORKER SCENARIO

TABLE OF CONTENTS

LIST OF TABLES

APPENDIX A
ENVIRONMENTAL PROTECTION AGENCY'S
TECHNICAL REVIEW WORKGROUP FOR LEAD

A.1 INTRODUCTION

The United States Environmental Protection Agency's (EPA's) Technical Review Workgroup for Lead (TRW) has developed interim guidance for assessing lead risks and establishing cleanup goals that will protect adults and fetuses from lead in soil (EPA 1995). The guidance does not provide a specific target soil lead cleanup level, but proposes a methodology which allows for the input of either site-specific data or recommended default values (selected from "plausible ranges" of values) to assess risk and develop site-specific cleanup goals. The methodology is very conservative (health-protective) because it is designed to protect developing fetuses, who may be more sensitive to the effects of lead than are adults. Therefore, cleanup goals developed using this methodology are much lower than those required for protection of adults only.

The EPA TRW adult lead model was used to derive an action (cleanup) level for lead in soil at the Union Pacific Omaha Shops, assuming a commercial worker scenario. Because the methodology used to derive the action level was only recently developed, detailed discussions of the methodology and associated rational are provided. The report is organized into the following sections:

- Background
- Basis and Assumptions for the Adult Lead Model
- Methodology
- Selection and Justification of Parameter Values
- Estimation of Action Level for Omaha Shops
- Summary and Conclusions

A.2 BACKGROUND

EPA has issued guidance on assessing lead risk and setting soil cleanup levels for residential land use (EPA 1989 and EPA 1994), but, until recently, no EPA guidance had been developed for assessing exposure and risk from industrial and commercial land use where only adults are exposed. EPA's 1989 guidance for residential exposure recommended cleanup levels from 500 to 1000 mg/kg based on blood lead levels in children (EPA 1989). The 1994 guidance recommended use of EPA's Integrated Exposure Uptake Biokinetic (IEUBK) model to estimate cleanup levels (generally around 400 mg/kg lead in soil) for residential exposure based on health effects in young children, ages 0 to 6 years, but did not provide guidance for evaluating adult exposure to lead in soil (EPA 1994).

EPA has stated that the EPA IEUBK Model for children was inappropriate for establishing cleanup levels based on adult exposures (EPA 1995). For lack of a better approach, many agencies have used the upper end of the 500 to 1000 mg/kg cleanup range (specified in EPA's 1989 guidance for lead at residential sites where children are exposed) to establish cleanup levels for industrial and commercial sites where only adults are exposed. This cleanup level range is not health-based for adult exposure because it was developed based on blood lead levels in children who have much higher soil ingestion rates, lead uptake rates, and resultant blood lead levels than similarly exposed adults.

In 1994, EPA's TRW began exploring methodologies to evaluate non-residential (adult) exposure to lead in soil. Existing blood lead models were considered, including those by Leggett (1993), O'Flaherty (1991, 1993, 1995), and Bowers et al. (1994). In October, 1995 the TRW released a memorandum (EPA 1995) which evaluated an EPA Region 8 methodology (a modified version of the Bowers adult lead model) used to derive a screening level of 13,900 mg/kg for lead in soil for a commercial land use scenario at the California Gulch (Leadville) Superfund site (Weston 1995a). The memorandum:

1. Stated that the proposed approach (use of the modified Bowers model) was a reasonable methodology for deriving soil cleanup goals and was consistent with agency guidance,

2. Defined plausible ranges of parameter values for the model and discussed the scientific justification for each parameter value range, and,

3. Revised several parameter values to the adult lead model for the California Gulch site and derived a soil cleanup goal of 11,200 mg/kg.

A TRW subcommittee on adult lead risk assessment was formed in January 1996 to refine the methodology and to prepare a "fact sheet" planned to be released at the national level in late 1996. The basic methodology in the fact sheet is expected to be very similar to that used in the 1995 memorandum. Although the TRW adult lead methodology has not yet been officially released, the approach has already been used (1) by EPA Region 8 to derive a soil lead screening level at the California Gulch (Leadville) Superfund site of 13,900 mg/kg for a commercial land use scenario (Weston 1995a), (2) by EPA Region 8 to derive a soil screening level of 16,000 mg/kg for an adult recreational scenario (Weston 1995b), and (3) to derive soil lead cleanup goals ranging from 2000 to 3000 mg/kg for commercial land use scenarios at other CERCLA/RCRA sites in EPA Regions 6 and 8 (Susan Griffin, EPA TRW, personal communication).

A.3 BASIS AND ASSUMPTIONS FOR THE TRW ADULT LEAD MODEL

The primary assumption in the TRW methodology is that the receptor of concern in the workplace is the fetus. The TRW methodology assumes that fetuses, like children, are more sensitive to the effects of lead in blood than are adults (the generally accepted blood lead level of concern in children is 10 micrograms per deciliter [μg/dL] [ATSDR 1993], whereas that for adults is 30 μg/dL [FDA 1990; Carrington and Bolger, 1992]). The approach of setting standards for lead in the workplace based on protection of fetuses has been used before. For example, the Occupational Safety and Health Administration (OSHA) standards for worker exposure to lead are those that result in (1) blood lead levels of less than 40 μg/dL for the general worker population and (2) blood lead levels of less than 30 μg/dL for workers who "intend to parent in the near future ..... to minimize adverse reproductive health effects to the parents and developing fetus" (OSHA 1993). The American Conference of Governmental Industrial Hygienists (ACGIH) recommends that blood lead levels for a woman in the workplace remain below 30 μg/dL, "to protect her ability to have children that can develop normally" (ACGIH 1994). However, the approach recommended by the EPA TWR is much more conservative than these previous approaches, because the maternal blood lead level of concern for protection of fetuses is assumed to be closer to 10 µg/dL.

The EPA TRW methodology (EPA 1995) relates soil lead concentration to blood lead concentration (PbB) in the mother and developing fetus based on the following additional assumptions:

- Fetal blood lead levels are proportional to maternal blood lead levels.
- Maternal blood lead levels can be predicted based on starting blood lead concentrations and an expected site-related increase.
- The site-related increase in maternal blood lead concentrations can be estimated using a linear biokinetic slope factor (BKSF) which is multiplied by the estimated lead uptake.
- Lead uptake can be estimated based on concentrations of lead in soil and assumptions regarding adult soil ingestion rates and the estimated absorbed fraction of ingested lead from soil.
- A lognormal model can be used to estimate the distribution of blood lead concentrations in a population of individuals who contact similar environmental lead levels.

The adult lead model can be used to estimate cleanup levels for lead in soil by back calculating soil lead concentrations that correspond to (1) a specific acceptable blood lead concentration distribution in mothers and fetuses and (2) site-specific or default exposure assumptions. The target blood lead distribution recommended by EPA for a population of women of child-bearing age is set such that greater than 95 percent of the fetuses in a population of women are predicted to have blood leads levels of 10 µg/dL or less (EPA 1995).

A.4 METHODOLOGY

The TRW adult lead model can be used to estimate the geometric mean blood lead concentration in adults based on soil lead concentrations using the following equation.

$$PbB_{GM} = PbB_0 + \left(\frac{Pb_s * BKSF * IR_s * AF_s * EF_s}{AT} \right) \quad \text{Equation 1}$$

where:

PbB_{GM} = geometric mean estimate of blood lead concentrations in adults (i.e., women of child-bearing age) that have site exposures (µg/dL).

PbB_0 = Background blood lead concentrations in women of child-bearing age in the absence of exposures to the site (µg/dL).

Pb_s = Average soil lead concentration (µg/g).

BKSF = Biokinetic slope factor relating increase in typical adult blood lead level to average daily uptake of lead (µg/dL blood lead increase per µg/day lead uptake).

IR_s = Intake rate of soil, including soil contained in indoor dust (g/day)

AF_s = Gastrointestinal absorption fraction for ingested lead in soil and dust (unitless).

EF_s = Exposure frequency for contact with soils and/or dust (days/year)

AT = Averaging time (365 days/year)

Equation 1 can be rearranged to calculate the soil lead action level associated with a given exposure scenario and target adult blood lead concentration distribution, resulting in the following equation:

$$Action\ Level = Pb_s = \frac{(Target\ PbB_{GM}) * AT}{BKSF * IR_s * AF_s * EF_s} \quad \text{Equation 2}$$

The action level represents the soil lead concentration that would be expected to result in a target adult blood lead concentration distribution and the corresponding 95th percentile fetal blood lead concentration. The target PbB_{GM} and associated blood lead concentration distribution are not constants, instead the target PbB_{GM} is calculated based on GSD_i (which may vary from site to site), $PbB_{95thfetal}$, and R values (each described below) and assuming that PbB_{GM} reflects the geometric mean of a lognormal distribution of blood lead concentrations in women of child-bearing age. The following equation is used to calculate the target PbB_{GM}:

$$Target\ PbB_{GM} = \frac{\frac{PbB_{95thfetal}}{R}}{Adult\ GSD_i^{\ 1.645}} \qquad \text{Equation 3}$$

where:

$PbB_{95thfetal}$ = Target 95th percentile blood lead concentration (mg/dL) among fetuses in a population of exposed women.

R = Constant of proportionality between fetal and maternal blood lead concentration.

$\frac{PbB_{95thfetal}}{R} = PbB_{95thmaternal}$ = Target 95th percentile blood lead concentration (mg/dL) in a population of exposed women, based on a target 95th percentile blood lead concentration (mg/dL) among fetuses.

Adult GSD_i = Estimated value of the individual geometric standard deviation among women of child-bearing age in the exposed population. This value represents the expected variation in blood lead levels from a population of women that have exposures to similar on-site lead concentrations, but have a non-uniform response (intake, absorption, biokinetics) to lead exposures. As discussed in Section 1.5.3, the GSD_i is site-specific, depending on characteristics of the exposed population. The exponent, 1.645, is the value used to calculate the 95th percentile from a lognormal distribution of blood lead.

A.5 SELECTION AND JUSTIFICATION OF PARAMETER VALUES

This section discusses the selection of parameter values for use in the TRW adult lead model at the Omaha Shops. As discussed above, the EPA TRW methodology recommends input of site-specific data into the adult lead model where feasible and the use of default values, selected from "plausible ranges" of values, when site-specific information is not available (EPA 1995). Table A-1 shows the TRW recommended plausible ranges of values for the parameters, the parameter values used to derive an action level for lead at the Omaha Shops, the basis for selecting each parameter value, and the uncertainty associated with each value. The following section provides additional discussion of these issues.

A.5.1 Target 95th Percentile Fetal Blood Lead Concentration ($PbB_{95thfetal}$)

The EPA TRW reported that the weight-of-evidence from the scientific literature suggests that delayed or impaired neurodevelopment during the first 12 months of postnatal life can be associated with maternal blood lead levels during pregnancy or neonatal blood lead levels at birth (EPA 1995). The TRW did not evaluate the scientific literature to determine the blood lead concentrations that are associated with adverse effects on the fetus. Instead, a fetal blood lead level of 10 μg/dL was selected based on the assumption that the blood lead level of concern for fetuses is the same as that for children. Using the EPA TRW recommended value of 0.9 for R (Section A.5.2), a fetal blood lead level of 10 μg/dL is associated with a maternal blood lead level of 11.1 μg/dL.

The TRW assumption that 11.1 μg/dL is the maternal blood lead level of concern for fetuses is not universally accepted. As discussed in Section A.3, OSHA and ACGIH currently consider the maternal blood lead level of concern for protection of the fetus to be 30 μg/dL. In the current assessment, the more conservative (health-protective) assumption that the maternal blood lead level of concern is 11.1 μg/dL (associated with a fetal blood lead level of 10 μg/dL) was used.

A.5.2 Constant Of Proportionality Between Fetal And Maternal Blood Lead Concentration (R)

The EPA TRW has recommended a fetal/maternal blood lead ratio of 0.9, based on weight-of-evidence from studies that have explored the relationship between cord and maternal blood lead (Goyer 1990, EPA 1986, 1989a). The strongest evidence supporting this value is from a study by Graziano et al. (1990) comparing maternal blood lead and umbilical cord blood lead at delivery in 888 mother-infant pairs between 28 and 44 weeks of gestation. The relationship between maternal blood lead and umbilical cord blood lead was linear with a slope of 0.93.

The distribution of parameters (i.e., the variation and uncertainty) for R is not well understood, therefore, a "plausible range" of values was not presented for this parameter. The value for R used in the current risk assessment was 0.9.

A.5.3 Individual Blood Lead Geometric Standard Deviation (GSD_i)

The EPA TRW acknowledges that there is uncertainty associated with this parameter and recommends that site-specific blood lead data be collected wherever possible. In the absence of site-specific blood lead data, the TRW suggests that the value be selected from the "plausible range" of values of 1.8 to 2.1, with 1.8 representing the GSD_i for homogenous populations, and 2.1 representing the GSD_i for diverse, urban populations. For this risk assessment, the GSD_i selected (1.95) was based on site-specific demographics - e.g., a worker population that is racially mixed (whites and blacks) yet socioeconomically homogeneous (primarily middle-income workers who reside in the suburbs).

A.5.4 Target Maternal Geometric Mean Blood Lead Concentration (Target PbB_{GM})

The value for this parameter (3.7 μg/dL) was calculated by using Equation 3, based on values for $PbB_{95thfetal}$, R, and GSD_i. This target PbB_{GM} is associated with a 95th percentile maternal blood lead concentration of 11.1 μg/dL and a 95th percentile fetal blood lead concentration of 10 μg/dL.

A.5.5 Geometric Mean Blood Lead Concentrations In Women Of Child-Bearing Age From Background Exposure To Lead (PbB_0)

The EPA TRW recommends PbB_0 (μg/dL) values of 1.7 for whites, 2.0 for Hispanics, and 2.2 for blacks. The higher blood lead values for black and Hispanic females may be related more to socioeconomic factors such as place of residence than to actual racial differences (e.g., lead in soil and dust is higher in urban areas than in rural areas, because lead from automobile exhaust and lead-based paint has had a greater impact on soil and dust in urban areas). For this risk assessment, the PbB_0 selected (1.95 µg/dL) was based on site-specific demographics - a worker population that is racially mixed (whites and blacks). This estimate may overestimate the actual PbB_0 value at the site, if most workers live in suburban, rather than urban, areas.

A.5.6 Biokinetic Slope Factor (BKSF)

EPA TRW recommends a BKSF of 0.4 (µg/dL per µg lead uptake from water/day) for adults based on an evaluation of Pocock et al. (1983). This value is based on the assumption (derived from the Pocock analysis) that the slope factor for lead <u>ingested</u> in water is 0.08 (µg/dL per µg lead ingested in water/day) and the fraction of lead absorbed from water by pregnant women is 0.20 (Section 1.5.8). The BKSF for lead <u>uptake</u> from water was back calculated by TRW as: 0.4 µg/dL per µg lead uptake/day = (0.08 µg/dL per µg lead ingested/day)/0.20.

Bowers et al. (1994) also analyzed the Pocock study and derived a similar BKSF of 0.375 µg/dL per µg lead uptake/day. FDA used a slope factor of 0.04 µg/dL per µg lead ingested/day (which translates to 0.2 µg/dL per µg lead uptake/day) to derive their provisional tolerable daily intake level of lead for pregnant women (Carrington et al. 1993). The California EPA Leadspread model uses a BKSF of 0.018 µg/dL per µg lead ingested/day to estimate cleanup goals for adult industrial exposure to lead in soil (which also translates to 0.2 µg/dL per µg lead uptake/day) (Cal EPA 1992). A BKSF of 0.14 µg/dL per µg lead uptake/day for adults was proposed recently by Appling et al. (1996), based on an analysis of the Kehoe human studies. Each of these slope factors is lower (less conservative) that the slope factor recommended by the EPA TRW.

The 0.375 µg/dL per µg lead uptake/day value recommended by Bowers et al. (1994) was selected for use in this risk assessment. This generally accepted value is near the upper end of the range of values in the scientific literature. The use of a lower BKSF would result in a higher action level for lead in soil (e.g., use of the 0.14 value proposed by Appling et al. [1996] would result in a 2.7-fold increase in the action level).

A.5.7 Daily Soil Ingestion Rate (IRs)

For the commercial worker, the soil ingestion value selected should represent a low-impact exposure scenario such as an office worker exposed indoors to soil in indoor dust (Pat Van Leeuwen, EPA TRW, personal communication). The EPA TRW recommended using a central tendency (average) soil ingestion value in the adult lead model, selected from a "plausible range" of 0.020 to 0.050 g/day (EPA 1995). EPA guidance does not contain a standard default value for average soil ingestion by commercial workers. EPA's standard default RME (upper end) value for soil ingestion for the commercial worker is 0.050 g/day (EPA 1991). It does not seem plausible that this upper end value for soil ingestion by indoor commercial workers would also be equal to the central tendency value. This suggests that the upper end of the TRW range of values (0.050 g/day) does not represent the average value as recommended by TRW for use in the lead model.

Bowers et al. (1995) and the California EPA Leadspread model (Cal EPA 1992) each recommend using 0.025 g/day as the average value for assessing risk to commercial workers from exposure to lead in soil. Results of a recent adult soil ingestion study (presented at the 1995 Soil Ingestion Workshop and submitted for publication) suggest that the average soil ingestion rate for adults may be as low as 0.001 (median) to 0.006 g/day (average) (Ed Calabrese, personal communication). Based on this review of available information, 0.025 g/day was selected as a reasonable average soil ingestion rate for commercial workers.

A.5.8 Absolute Gastrointestinal Absorption Fraction For Ingested Lead In Soil And Dust (AF_s)

The EPA TRW recommended an AFs value of 0.12, based on the assumptions that (1) adults absorb about 10 percent of lead from water, (2) pregnant women absorb about twice as much lead from water (20 percent) as do nonpregnant adults, and (3) absorption of lead from soil is 0.6 of that from water (due to matrix effects). The assumption that pregnant women absorb twice as much lead as non-pregnant adults is not based on experimental evidence, but on increased calcium absorption during pregnancy. Therefore, there is uncertainty associated with TRW's use of 20 percent absorption of lead in pregnant women. The assumed matrix effect of 0.6 is based on the TRW assumption that children absorb 50 percent of lead from water, but only 30 percent of lead from soil (0.3/0.5 = 0.6) (EPA 1995). Because the TRW adult model was developed to establish cleanup goals for adult exposure to lead in soil, a better matrix factor for this purpose is 0.50 based on studies on fasted adult humans showing that absorption of lead from soil is approximately one-half of absorption of lead from water (Heard and Chamberlain, 1982, Maddaloni et al. 1996). This 0.50 matrix factor is similar to the 0.44 factor, based on bioavailability studies on rats (Chaney et al. 1990), used by the California EPA Leadspread model to evaluate risk to industrial workers from exposure to lead in soil (Cal EPA, 1992).

Therefore, a AF_s of 0.10 was selected for use in this risk assessment, assuming conservatively that pregnant women absorb 20 percent of lead from water and using a factor of 0.5 to represent the matrix effect of soil. This matrix factor is consistent with the matrix factor of 0.5 used for other chemicals in the screening level risk assessment on the Omaha Shops (W-C 1994).

A.5.9 Exposure Frequency

The EPA standard default RME exposure frequency of 250 days/year for commercial workers was used. This exposure frequency was also used for the commercial worker scenario in the screening level risk assessment (W-C 1994), and is recommended by the EPA TRW for use in the adult lead model.

A.5.10 Averaging Time

An averaging time of 365 days was used, per EPA guidance regarding continuing long-term exposures.

A.5.11 Summary Of Parameters Used

Parameter values used (Table A-1) were generally consistent with EPA TRW guidance (EPA 1995) in that:

- Values for R, $PbB_{95thfetal}$, $PbB_{95thmaternal}$, and EF_s were identical to those proposed by the EPA TRW (EPA 1995)

- Site-specific values for GSD_i and PbB_0 were selected based on worker population demographics, per EPA TRW guidance (EPA 1995)

- The value for IR_s (0.025 g/day) was within the TRW "plausible range" of values for this parameter, was consistent with soil ingestion estimates in other generally accepted adult lead models, and was larger than the value used by the EPA TRW for commercial workers (0.020 g/day) in the evaluation of the California Gulch site (EPA 1995)

- The value for BKSF (0.375 µg/dL per µg/day) was slightly smaller than that proposed by the TRW (0.4 µg/dL per µg/day), but it is a reasonable value from a well-recognized adult lead model (Bowers et al. 1994) and is near the upper end of values for BKSF reported in the scientific literature.

- The value for AF_s (0.10) was slightly smaller than that proposed by the EPA TRW (0.12), but was based on a more appropriate matrix factor of 0.5 derived for adult exposure (instead of 0.6, derived based on childhood exposure) and was consistent with the matrix factor used in the screening level risk assessment for the Omaha Shops (W-C 1994).

A.6 ACTION LEVEL ESTIMATE FOR OMAHA SHOPS

An action level of 2725 µg/g (ppm) lead in soil was estimated using equations 2 and 3 and parameter values in Table 1-1 as shown below:

$$\frac{\frac{10\mu g/dl}{0.9}}{1.95^{1.645}} = 3.70\mu g/dl = Target\ PbB_{GM} \qquad \text{Equation 4}$$

$$\frac{(3.70\mu g/dl - 1.95\mu g/dl) * (365 days/year)}{0.375\mu g/dl\ per\ mg/day * 0.025\ g\ soil/day * 0.10 * 250\ days/year} = 2{,}725\mu g/g = Action\ Text \qquad \text{Equation 5}$$

Based on the parameters selected, the TRW model predicts that exposure to lead in soil at the Omaha Shops at a concentration of 2725 mg/kg (2725 µg/g * 1000 g/kg * 1 mg/1000 µg = 2725 mg/kg) would result in greater than 95 percent of fetuses in a population of commercial workers having blood lead levels of 10 μg/dL or less. This is the target fetal blood lead distribution identified in EPA TRW guidance as posing an acceptable level of risk (EPA 1994b). The action level is based on conservative site-specific parameter values and is expected to be health protective for fetuses. Because adults may be less sensitive than fetuses to the effects of lead in blood, the action level is likely overly protective of adult commercial workers.

A.7 SUMMARY AND CONCLUSIONS

An action level of 2725 mg/kg lead in soil was derived for the Union Pacific Railroad Omaha Shops assuming a commercial worker scenario for adults, potentially including pregnant women. The action level was derived using interim guidance developed by EPA's Technical Review Workgroup for Lead (TRW) for assessing lead risks and establishing cleanup goals that will protect adults and fetuses from lead in soil (EPA 1995). The action level was derived based on assumptions regarding soil ingestion, lead uptake, and resulting blood lead levels in adults (rather than in children). Therefore, the action level is a more appropriate estimate of health-protective cleanup levels for adult and fetal exposure to lead in soil than are levels selected from the generic 500 to 1000 mg/kg range derived by EPA (1989) based on blood lead levels in children.

The TRW guidance does not provide a specific target soil lead cleanup level, but proposes a methodology which allows for the input of either site-specific data or recommended default values (selected from "plausible ranges" of values) to assess risk and develop site-specific cleanup goals. In the current risk assessment, parameter values for the model were selected based on site-specific information, EPA TRW default values, and information from the scientific literature. Based on the parameters selected, the TRW model predicts that commercial worker exposure to lead in soil at the site at a concentration of 2725 mg/kg would result in greater than 95 percent of fetuses having blood lead levels of 10 micrograms of lead per deciliter of blood (μg/dL) or less. This is the target fetal blood lead distribution identified in EPA TRW guidance as posing an acceptable level of risk (EPA 1994b). Because adults may be less sensitive than fetuses to the effects of lead in blood, the action level is likely overly protective of adult commercial workers.

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TABLE A-1

PARAMETER VALUES USED WITH EPA TRW METHODLOGY TO DERIVE AN ACTION LEVEL FOR LEAD IN SOIL FOR THE COMMERCIAL WORKER SCENARIO

Model Parameter	Parameter Description	Plausible Range of Parameter Values Proposed by EPA TRW	Parameter Value Selected	Units	Basis	Uncertainty
GSD_i	Individual blood lead geometric standard deviation	1.8 (homogeneous population) 2.1 (heterogeneous population)	1.95	unitless	Worker population is mixed racial (whites and blacks) and socioeconomically homogenous.	Value is consistent with site-specific demographics.
R	Fetal/maternal blood lead ratio	0.9	0.9	µg lead/dl maternal blood per µg lead/dl fetal blood	Weight-of-evidence from scientific literature.	Value is well supported in the scientific literature.
$PbB_{95thfetal}$	95th percentile blood lead concentration in fetus	10	10	µg/dl	TRW assumption that the blood lead level of concern in fetuses is the same as that in children.	Experimental results supporting a fetal blood lead level of concern of 10 µg/dl were not available. However, in the absence of experimental data, it is reasonable to assume that fetuses and children have similar sensitivity to lead.
$PbB_{95thmaternal}$	95th percentile maternal blood lead concentration	11.1	11.1	µg/dl	The TRW assumed maternal blood lead level of concern for protection of the fetus.**	Value is much smaller than that (30 µg/dl) used to set other standards in the workplace (OSHA 1993, ACGIH 1994).
Target Pb_{GM}	Target geometric mean maternal blood lead concentration	Calculated value	3.70	µg/dl	-	-
PbB_0	Baseline blood lead concentration	1.7 (whites) 2.0 (hispanics) 2.2 (blacks)	1.95	µg/dl	Worker population is mixed racial (whites and blacks) and socioeconomically homogenous.	Value is consistent with site-specific demographics.
BKSF	Biokinetic slope factor	0.4	0.375	µg/dl per µg uptake/day	Based on Bowers et al. (1994).	Value is near the upper end of the range of values reported in the scientific literature.
IRs	Soil/Dust Ingestion Rate	0.020 to 0.05	0.025	g/day	Average soil ingestion rate for commercial workers proposed by Bowers et al. (1994) and the California EPA Leadspread model (Cal EPA 1992).	The upper end of the TRW range (0.050) is considered unrealistic (see Section 1.5.7). The value used (0.025) is within the TRW range and is a reasonable estimate of average soil ingestion.
AFs	Oral absorption of lead in soil	0.12	0.1	unitless	Assumes (1) absorption fraction for lead in water in pregnant women (0.20) is twice that of nonpregnant adults and (2) a soil matrix factor of 0.5.	The matrix factor used (0.5) is based on experimental results in adult humans, whereas that proposed by TRW (0.6) is based on matrix effects in children.
EFs	Exposure frequency	250	250	days/year	EPA standard default value. Assumes at work 5 days/week for 50 days/year.	High-end default value likely overestimates exposure for most workers, but is consistent with the conservative methodology used in the screening level risk assessment (W-C 1994).

*$PbB_{95thmaternal} = PbB_{95thfetal}/R$

**based on the concentration in maternal blood that would result in a concentration in fetal blood of 10 mg/dl, using an R value of 0.9

APPENDIX B

HUMAN HEALTH RISK ASSESSMENT FOR CONSTRUCTION WORKER EXPOSURE TO GROUNDWATER

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HUMAN HEALTH RISK ASSESSMENT FOR CONSTRUCTION WORKER EXPOSURE TO GROUNDWATER

B.1 INTRODUCTION

Commercial development may be considered for the Union Pacific Railroad (UPRR) Omaha Shops and Maintenance Facility site. Because groundwater beneath the UPRR Omaha Shops site is shallow, construction workers may be exposed to groundwater during site development activities. A human health risk assessment was used to evaluate whether chemicals detected in groundwater at the site could potentially pose an unacceptable risk to human health. The following sections discuss the methodology and results of the baseline risk assessment for groundwater at UPRR Omaha Shops.

B.1.1 Objectives and Methodology

The baseline human health risk assessment was used to assess potential adverse health effects associated with exposure to groundwater at the UPRR Omaha Shops. No further action is proposed to control or mitigate releases (i.e., no corrective action) from identified source areas. To be consistent with the screening-level risk assessment of UPRR Omaha Shop soils (W-C 1994), only the reasonable maximum exposure (RME) scenario for groundwater exposures will be evaluated. The RME represents the highest plausible exposure for a site.

The risk assessment methodology used in this study is based on the guidance provided by the United States Environmental Protection Agency (EPA) in Risk Assessment Guidance for Superfund, Volume 1, Human Health Evaluation Manual (EPA 1989c). Other risk assessment guidance used included EPA Region I Supplemental Risk Assessment Guidance for the Superfund Program, Part 1 (EPA 1989a), EPA Risk Updates, EPA Data Usability Guidance (EPA 1990b), and Dermal Exposure Assessment: Principles and Applications and Exposure Factors Handbook (EPA 1992a). EPA cautions that their documents are intended to provide guidance only, and that considerable professional judgment must by exercised in applying the guidance to site-specific human health risk assessments. The steps in the baseline risk assessment process are:

1. Identification of chemicals of concern (COCs)
2. Exposure assessment
3. Toxicity assessment
4. Risk characterization (including an evaluation of uncertainties in the risk assessment)

These steps are described in the following sections.

B.2 IDENTIFICATION OF CHEMICALS OF CONCERN

Chemicals of concern (COCs) are compounds that may have been released from waste sources at the site, have been detected in environmental media (e.g., groundwater) at the site, and may pose human health risks. As a general rule, COCs include all organic compounds that are detected with greater than 5 percent frequency, and that may be site-related (e.g., are not determined to be field or laboratory contaminants). Metals of concern are those that may be related to activities at the site, and that occur in concentrations that statistically exceed background levels. COCs that do not have EPA-established toxicity factors were not evaluated quantitatively in the risk assessment, but their potential contribution to overall risk was addressed qualitatively.

B.2.1 Use of Data

Groundwater was evaluated as one unit for the UPRR Omaha Shops rather than on a site by site basis. This is appropriate because it is likely that construction workers would be involved in excavation activities throughout the entire site. Monitoring data from 14 monitoring wells and the sump at the Gas House were used in the risk assessment. These data were collected as part of the Phase I Site Assessment (HDR 1990).

B.2.2 Comparison of Site Data with Background Concentrations of Metals

Metals are naturally occurring constituents in soil and water. Therefore, a comparison of site sample concentrations to background concentrations can be used to assess whether metals in environmental samples may be naturally occurring or may be site related. A metals background comparison was not feasible for this risk assessment because background data for the site were not available. Therefore, all metals detected in the groundwater were considered COCs.

B.2.3 Availability of EPA Toxicity Criteria

Chemicals of potential concern for which EPA-published toxicity factors (i.e., reference doses or cancer slope factors) are not available were evaluated qualitatively in the risk assessment since quantitative risk characterization is not possible without these factors. Chemicals without toxicity factors were also addressed qualitatively in the uncertainties section of the risk assessment. The sources of toxicity values are EPA's Integrated Risk Information System (IRIS) database (IRIS 1994; 1995); the Health Effects Assessment Summary Tables (HEAST) (EPA 1993; 1994); Hazardous Substances Database (HSDB 1994; 1995), which is supported by the Agency for Toxic Substances and Disease Registry (ATSDR); or provisional values published by EPA in technical memoranda.

B.2.4 Site Chemicals of Concern

Chemicals detected in groundwater at the UPRR Omaha Shops included volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), pesticides, polychlorinated biphenyls (PCBs), total petroleum hydrocarbons (TPH), and metals. All organic chemicals detected in groundwater were considered to be COCs. As discussed in Section A.2.2, a background comparison for metals detected in groundwater was not done. Therefore, all metals detected in groundwater were considered to be COCs. These metals include arsenic, beryllium, cadmium, chromium, copper, lead, mercury, nickel, selenium, and zinc.

Lead, 2-methylnaphthalene, and delta-BHC (delta-benzenehexachloride or delta-Lindane) do not have EPA-established toxicity factors; therefore, they can not be evaluated in the quantitative risk assessment. However, they were retained as COCs and their contribution to the total risk at the site was addressed qualitatively.

Provisional toxicity factors for #2 fuel oil, #2 diesel, and gasoline were used in the risk assessment. The provisional toxicity values are based on inhalation studies in animals using fresh fuel product. They are most appropriately used for evaluating exposures to fresh fuel spills if analytical results for the toxic constituents of TPH (primarily benzene, toluene, ethylbenzene, and xylenes) are not available, and if the fuel product is known. The provisional toxicity factors for fuel have been withdrawn (EPA 1992d), but to be consistent with the screening-level risk assessment of UPRR Omaha Shops soils (W-C 1994), they were used to evaluate groundwater at the site. Table A-1 lists the COCs in groundwater.

B.3 EXPOSURE ASSESSMENT

B.3.1 Receptors and Exposure Pathways

Groundwater is not used for domestic purposes at or downgradient of the site. However, the groundwater beneath UPRR Omaha Shops is very shallow from 3 to 15 feet below ground surface and construction workers may be exposed to groundwater during site development activities. The routes by which future construction workers may be exposed are:

- Incidental ingestion of groundwater
- Dermal contact with groundwater
- Inhalation of volatile emissions from groundwater

B.3.2 Exposure Point Concentrations in Groundwater

The maximum detected concentrations of COCs detected in groundwater were used as the RME exposure point, and are summarized in Table A-2. Table A-3 shows the exposure point concentrations (adjusted) used for the dermal contact pathway. The adjusted concentrations were calculated by multiplying the RME concentrations by chemical-specific permeability coefficients. The dermal permeability coefficients were taken from Dermal Exposure Assessment: Principles and Applications (EPA 1992a).

B.3.3 Emissions from Groundwater

An EPA box model (EPA 1988a) was used to estimate volatile emissions from surface water. The model was also used to estimate air concentrations of volatile emissions from groundwater in hypothetical excavations that might encounter groundwater. The box model is very conservative because it assumes that conditions are steady state, and it does not account for dilution or dispersion in the atmosphere between the source and the receptor.

Volatile emissions were calculated from the RME groundwater concentrations of COCs. Table A-4 presents the calculated air concentrations from groundwater.

The equations used to estimate the concentration in air of volatile emissions from groundwater and surface water are presented here:

Overall Mass Transfer Rate

$$Kl = \frac{1}{\frac{1}{k_l} + \frac{RT}{H k_g}} \qquad \text{Equation 1}$$

Where:

Kl = Overall mass transfer coefficient (cm/hr)

k_l = Liquid phase mass transfer coefficient (cm/hr) (chemical-specific)

k_g = Gas phase mass transfer coefficient (cm/hr) (chemical-specific)

R = Gas constant = $8.2 * 10^{-5}$ atm-m^3/mol °K

T = Absolute temperature (°K)

H = Henry's Law Constant (atm-m^3/mol) (chemical-specific)

Flux of Vapors to Air

$$Fa = Kl * Cw \qquad \text{Equation 2}$$

Where:

Fa = Mass flux to atmosphere (mg/hr-cm^2)

Kl = Overall mass transfer coefficient (cm/hr)

Cw = Maximum detected concentration of volatile compound in water (mg/cm^3)

Emission Rate of Vapors

$$Q = Fa * A \qquad \text{Equation 3}$$

Where:

Q = Vapor emission rate (g/hr)

Fa = Mass flux to atmosphere (g/hr-cm^2)

A = Area from which emissions occur (cm^2) (area of construction trench)

Ambient Air Concentrations Using EPA Box Model (EPA 1988a)

$$Ca = \frac{Q}{LS * V * MH} \qquad \text{Equation 4}$$

Where:

Ca = Ambient air concentration (mg/m^3)

Q = Emission rate of vapors (g/sec)

LS = Equivalent side length of site perpendicular to wind direction (m)

V = Average annual wind velocity (m/sec)

MH = Mixing height (m)

Construction workers were assumed to be exposed to a small excavation area (15 m x 5 m), such as a trench, where the wind velocity in the breathing zone was assumed to be 1m/sec (3,600 m/hr), to be conservative. This wind velocity is less than the standard default exposure factor (SDEF) wind velocity, which is the value estimated for 2m (mixing height) above ground.

B.4 ESTIMATING CHEMICAL INTAKES

Using the exposure point concentrations of COCs in groundwater, it is possible to estimate the potential human intake of those chemicals via each exposure pathway. Intakes are expressed in terms of milligrams of chemical per kilogram of body weight per day (mg/kg-day). Intakes are calculated following guidance in Risk Assessment Guidance for Superfund (EPA 1989c), Exposure Factors Handbook (EPA 1989b), other EPA guidance documents as appropriate, and professional judgment regarding probable exposure conditions. Intakes are estimated using reasonable estimates of body size, inhalation rates, ingestion rates, dermal absorption rates, and frequency and duration of exposure.

Intakes are estimated for RME conditions. The RME is estimated by selecting values for exposure variables so that the combination of all variables results in the maximum (high end) exposure that can reasonably be expected to occur at the site. In this risk assessment, the RME scenarios are developed using EPA's Standard Default Exposure Factors (SDEFs) (EPA 1991a). These factors probably significantly overestimate actual exposures at the sites.

The general equation for calculating intake in terms of mg/(kg-day) is:

$$Intake = \frac{Chemical\ conc.\ *\ contact\ rate\ *\ exposure\ frequency\ *\ esposure\ duration}{body\ weight\ *\ averaging\ time} \quad \text{Equation 5}$$

The variable "averaging time" is expressed in days to calculate average daily intake. For noncarcinogenic chemicals, intakes are calculated by averaging the total cumulative dose over the period of exposure to yield an average daily intake. For carcinogens, intakes are calculated by averaging the total cumulative dose over a 70-year lifetime, yielding "lifetime average daily intake." Different averaging times are used for carcinogens and noncarcinogens because it is thought that their effects occur by different mechanisms. The approach for carcinogens is based on the current scientific opinion that a high dose received over a short period of time is equivalent to corresponding low dose spread over a lifetime. Therefore, the intake of a carcinogen, for whatever duration, is averaged over a 70-year lifetime (EPA 1989c).

Omitting chemical concentrations from the intake equation yields a pathway-specific "intake factor (in mg/kg-day per unit media concentrations)." Since the exposure pattern resulting in exposure to various COCs is the same, the intake factor (IF) can be calculated by multiplying it by the concentration of each chemical to obtain the pathway-specific intake of that chemical. Intake factors are calculated separately for each exposure pathway. The intake factors used in the risk assessment are presented in Tables A-5 through A-7. The assumptions used in deriving intake factors are discussed below.

B.4.1 Exposure Assumptions

B.4.1.1 General Exposure Assumptions

Several exposure parameters, such as exposure frequency and duration, body weight, and averaging times, have general application in all intake estimations, regardless of pathway. The general assumptions for the RME scenario are detailed below.

- The exposure duration of construction workers is 40 days/year (8 work weeks or 2 months), which is the estimated duration of excavation activities for a larger construction project (foundation for a large building).
- Construction workers are assumed to spend 8 hours/day at the site. This is equivalent to a typical work day.
- Construction worker exposure duration is assumed to be one year. This assumes that a construction project will be completed within a one-year time span.
- Averaging time for noncarcinogenic effects is based on exposure duration. Construction worker averaging time is 1 year (365 days).
- Averaging time for carcinogenic effects is 70 years (25,550 days) (EPA 1989a, 1989c).
- The average adult body weight is 70 kg (EPA 1989a, 1989c).

B.4.1.2 Groundwater Ingestion Assumptions

Uptake of COCs via incidental ingestion of groundwater is a function of the volume of water ingested per day and the frequency and duration of exposure. Intake factors for exposure via incidental groundwater ingestion were calculated for construction workers and are presented in Table A-5.

- Construction workers are estimated to ingest 10.0 mL/day of groundwater while working at the site. It is assumed that groundwater discharging into an excavated area will be removed and that incidental water ingestion will occur and that surface water ingestion rates can be estimated from soil ingestion rates. For example, 100 mg of saturated soil ingested per day would result in roughly 0.011 mL of water per day assuming a soil density of 2.65 g/cm^3 and a saturated porosity of 0.3. Therefore, the ingestion rate of 10 mL/day is highly conservative (up to 3 orders of magnitude) in relationship to the equivalent soil ingestion rate.

- The fraction ingested from the contaminated source is assumed to be 1.0. This assumes that all the groundwater ingested by construction workers in a day is from the contaminated area.

- Exposure time, exposure frequency, exposure duration, body weight, and averaging time for the ingestion pathway are discussed in the general assumptions section (A.4.1.1).

B.4.1.3 Dermal Absorption from Groundwater

Uptake of COCs through dermal contact with groundwater is a function of exposed body surface area, a permeability constant that describes the rate at which chemicals penetrate the skin, and exposure frequency and duration. Intake factors for exposure via dermal contact with groundwater were calculated for construction workers and are presented in Table A-6.

- The estimated exposed body surface area is 3,160 cm^2/day. This is equivalent to head, forearms, and hands (EPA 1989b). The worker is assumed to wear a uniform or civilian clothing appropriate for maintenance or other outdoor work.

- The permeability constant is a chemical-specific parameter used to adjust chemical concentrations for use in calculating risks for the dermal contact route. The permeability constant for inorganics was assumed to be 1×10^{-3} cm/hr, which is the default value for inorganics recommended in Dermal Exposure Assessment: Principles and Applications (EPA 1992a). For organics, chemical-specific permeability constants recommended by EPA (1992a) were used.

- Exposure time, exposure frequency, exposure duration, body weight, and averaging time for the dermal pathway are discussed in the general assumptions section (A.4.1.1).

B.4.1.4 <u>Inhalation Assumptions</u>

Intake of COCs through inhalation is a function of the volume of air inhaled per day (i.e., exposure time in hours multiplied by the volume of air inhaled per hour), the exposure frequency, and duration. Table A-7 presents the intake factors for exposure via inhalation.

- The RME inhalation rate is 2.5 m^3/hr. The RME rate is the SDEF from EPA (1991a) which is the rate corresponding to heavy work activities

- Exposure time, exposure frequency, exposure duration, body weight, and averaging time for the inhalation pathway are discussed in the general assumptions section (A.4.1.1).

B.5 TOXICITY ASSESSMENT

B.5.1 Introduction

EPA toxicity factors are used to assess potential health risks resulting from the estimated chemical intakes. Toxicity factors are expressed either as a reference dose (RfD) or a slope factor (SF). An RfD is the daily dose of a noncarcinogen that is unlikely to result in toxic effects to humans over a lifetime of exposure. RfDs are used to estimate the potential for noncarcinogenic effects of substances. Slope factors and the EPA's weight-of-evidence classification are used to estimate potential carcinogenic risks. The SF is an estimate of the upper-bound probability of an individual developing cancer as a result of exposure to a potential carcinogen. The weight-of-evidence classification is an evaluation of the quality and quantity of carcinogenic potency data for a given chemical. RfDs and SFs for noncarcinogenic and carcinogenic COCs are presented in Tables A-8 and A-9, respectively.

B.5.2 RfDs for Noncarcinogenic Effects

Substances that produce adverse noncarcinogenic effects are generally thought to have a threshold dose below which the adverse effects are not likely to be observed upon lifetime (chronic) or a portion of lifetime (subchronic) exposure. Chemical intakes that are expected to result in no adverse effects to humans are referred to by EPA as RfDs. The EPA defines a chronic RfD as an estimate of a daily exposure level for the human population that is unlikely to result in deleterious effects, even to sensitive subpopulations (e.g., the very young or very old), during a lifetime (70 years). A chronic RfD is used to evaluate the potential noncarcinogenic hazards associated with long-term chemical exposures (7 years to a lifetime).

Subchronic RfDs have been developed to characterize potential noncarcinogenic hazards associated with shorter term chemical exposures. The EPA defines subchronic exposure as periods ranging from 2 weeks to 7 years. Subchronic RfDs tend to be higher, generally by an order of magnitude, than chronic RfDs because for some chemicals, a higher dose can be tolerated for the shorter exposure duration.

To develop the RfD, the threshold dose or no-observed-adverse-effect level (NOAEL) is identified through studies with experimental animals. A NOAEL is an experimentally-determined highest dose at which there was no statistically or biologically significant effect of concern, often called the "critical toxic effect." For certain substances, only a LOAEL, or "lowest-observed-adverse-effect level", has been determined. This is the lowest dose of a substance that produces either a statistically or biologically significant indication of the critical toxic effect. The NOAEL or the LOAEL may be used to calculate the RfD of a particular chemical. EPA bases the RfD on the most sensitive animal species tested (i.e., the species that experience adverse effects at the lowest doses). In some cases, RfDs may be based on human epidemiologic data.

RfDs are generally calculated by dividing the NOAEL (or LOAEL) by uncertainty factors, which generally range from 1.0 to 1,000. Uncertainty factors are intended to account for specific types of uncertainty inherent in extrapolation from one exposure route to another, extrapolation of data from laboratory animals to humans, variations in species sensitivity, variations in sensitivity among individuals within a species, limitations in exposure duration in animal experiments, and other limitations in the experimental data. Experimental animal data have historically been relied upon by regulatory agencies and other expert groups to assess the hazards of human chemical exposures. Although this reliance has been generally supported by empirical observations, there are known interspecies differences in chemical adsorption, metabolism, excretion, and toxic responses. There are also uncertainties concerning the relevance of animal studies using exposure routes that differ from the human exposure routes under consideration. Additionally, extrapolating results of short-term or subchronic animal studies to long-term exposures in humans has inherent uncertainty.

Despite the many limitations of experimental animal data, such information is essential for chemical toxicity assessment, especially in the absence of human epidemiological evidence. The uncertainty factors used in the derivation of RfDs are intended to compensate for data effects that may occur when the adverse effect of one chemical is greater in the presence of a second chemical than if the exposure were to one chemical alone. Antagonistic effects may occur when two chemicals interfere with each other's actions or one interferes with the action of the other chemical.

The method of deriving human RfDs from short-term studies in sensitive animals is conservative by design and introduces the potential to overestimate, but very likely not underestimate, noncarcinogenic effects. The methodology for deriving RfDs is more fully described in the EPA's current human health risk assessment guidance (EPA 1989c). The RfD is expressed in units of milligrams of chemical per kilogram of body weight per day (mg/kg-day). For inhalation exposures, reference concentrations (RfCs) are commonly provided, expressed as milligrams of chemical per cubic meter of air (mg/m^3). A body weight of 70 kg and a respiration rate of 20 m^3/day are generally used to convert the reference air concentration (mg/m^3) to a dose (i.e., mg/kg-day).

EPA recognizes that, even with the application of uncertainty factors, RfDs and RfCs are provisional estimates with uncertainty perhaps spanning an order of magnitude or more (EPA 1993). EPA rates the confidence level of verified RfDs and RfCs as high, medium, or low.

B.5.3 Slope Factors for Carcinogenic Effects

In estimating the potential risk posed by potential carcinogens, it is the practice of the EPA and other regulatory agencies to assume that any exposure level has a finite probability, however minute, of producing a carcinogenic response. EPA assumes that a small number of molecular events can evoke changes in a single cell that can lead to uncontrolled cellular proliferation. This mechanism for carcinogenicity is referred to as "nonthreshold" since there is theoretically no level of exposure for such a substance that does not pose a small probability of producing a carcinogenic response. The EPA assigns the substance a weight-of-evidence classification that describes the likelihood, based on scientific evidence, that the substance is a human carcinogen. Given sufficient data, a slope factor is then calculated, with a selected computer model specific for the assumed mechanism of action for carcinogenesis, that describes quantitatively the relationship between average lifetime dose and carcinogenic risk.

The slope factors are based primarily on the results of animal studies. There is uncertainty whether animal carcinogens are also carcinogenic in one or more animal species, since only a small number of chemical substances are known to be human carcinogens. The EPA assumes that humans are as sensitive to all animal carcinogens as the most sensitive animal species. This policy decision introduces the potential to overestimate, but very likely not to underestimate, carcinogenic risk.

A number of mathematical models and procedures have been developed to extrapolate from carcinogenic responses observed at high doses in experimental animals to responses expected at low doses in humans. The EPA uses a linearized multistage model for low-dose extrapolation. This conservative mathematical model is based on the multistage theory of carcinogenesis wherein the response is assumed to be linear at low doses. The EPA further calculates the upper 95th percent confidence limit of the slope of the resulting dose-response curve. This value, the slope factor (SF), expressed in units of $(mg/kg\text{-}day)^{-1}$, is used to convert the average daily intake of a chemical, normalized over a lifetime, directly to an estimate of cancer risk. The resulting risk estimate represents an estimation of an upper-bound lifetime probability that an individual will develop cancer risk at low doses, and is likely to overestimate the actual cancer risk. The EPA acknowledges that actual risk is likely to be less than the estimate calculated with the SF using the linearized multistage model and in fact may be zero (EPA 1989c).

Sources and Uses of Toxicity Information

The result of toxicity assessments performed by EPA is the development of chemical-specific toxicity factors for either the inhalation or oral exposure pathway. These toxicity factors are available in the Integrated Risk Information System (IRIS 1994, 1995) and the Health Effects Assessment Summary Tables (HEAST) (EPA 1992; 1993; 1994). IRIS is an EPA database containing health risk and regulatory information for numerous chemicals. Only toxicity factors that have been verified by EPA science work groups are included in IRIS. HEAST may contain interim and subchronic toxicity factors that do not appear in IRIS. Toxicity information from these databases was used in the risk assessment. Critical toxicity information on noncarcinogenic and carcinogenic COCs is summarized in Tables A-8 and A-9, respectively.

B.6 RISK CHARACTERIZATION

Risk characterization combines outputs of the exposure and toxicity assessments to develop quantitative estimates of risks associated with exposures to COCs released from this site. The risk characterization should present the risk estimates in an unbiased manner and explain the uncertainties associated with the calculation of the risk estimates.

B.6.1 Hazard Index for Noncarcinogenic Effects

The potential for noncarcinogenic effects is characterized by comparing estimated chemical intakes with chemical-specific RfDs. The RfD is considered to be the average daily dose (in terms of milligrams chemical per kilogram body weight per day) that is not likely to result in adverse effects even to sensitive individuals over a lifetime of exposure. Chemical intake is the chemical concentration in the exposure medium multiplied by the pathway-specific intake factor. The ratio of the estimated intake to the RfD is called a hazard quotient, which is calculated as follows:

$$Noncancer\ Hazard\ Quotient = \frac{Chemical\ Intake\ (mg\ /\ kg - d)}{RfD\ (mg\ /\ kg - d)} \qquad \text{Equation 6}$$

If the average daily intake exceeds the RfD (that is, if the hazard quotient exceeds 1.0), there may be cause for concern for noncancer health effects. It should by noted, however, that the level of concern does not increase linearly as the RfD is approached or exceeded. This is because all RfDs have built-in safety or modify factors and are generally specific to experimental animals. Furthermore, the hazard quotient does not represent a statistical probability of an effect occurring. To assess noncarcinogenic hazards for construction workers, the subchronic RfDs, where available, were used. As indicated before, construction workers are expected to be on site for one year or less, in which case the subchronic RfDs are applicable. Where subchronic RfDs were not available, chronic RfDs were used.

Hazard quotients are summed for all COCs and their relevant exposure pathways to yield a total hazard index (HI). A hazard index equal to or less than 1.0 indicates that no adverse noncarcinogenic health effects are expected to occur even to sensitive individuals over a lifetime of exposure. A hazard index above 1.0 indicates a potential cause for concern for noncarcinogenic health effects and the need for further evaluation of assumptions about exposure and toxicity (for example, effects of several different chemicals are not necessarily additive, although the hazard index approach assumes additivity).

The assumption of additive effects reflected in the cumulative HI is most properly applied to substances that induce the same effect by the same mechanism (EPA 1986b). Consequently, application of the equation to a mixture of substances that are not expected to induce the same type of effects could overestimate the potential for adverse health effects. When the HI exceeds 1.0, a qualitative assessment of the major contributors to the HI was made to determine whether different target organ systems were affected. If different target organ systems were affected, the addition of the HQs may be causing an overestimation of adverse health effects. Therefore, each target organ system would be evaluated to assure that no one system has an HI greater than 1.0.

The HI provides a rough measure of potential toxicity, but it is conservative and dependent on the quality of the experimental evidence. Since the HI does not define dose-response relationships, its numerical value cannot be construed as a direct estimate of the magnitude of risk (EPA 1986b).

B.6.2 Carcinogenic Risk

Potential carcinogenic effects are characterized in terms of the excess probability of an individual developing cancer over a lifetime as a result of exposure to a potential carcinogen. Excess probability means the increased probability over and above and above the normal probability of getting cancer (i.e., background risk) which, in the Untied States, is 1 in 3 (American Cancer Society 1990). Excess cancer risks from exposure to chemicals released from hazardous waste sites are often below 1 in 10,000.

Excess lifetime cancer risk is calculated by multiplying the average daily chemical intake by the cancer SF, which is a risk-per-unit chemical intake:

$$Risk = Chemical\ Intake\ (mg / kg - day)\ x\ SF\ (mg / kg - day)^{-1} \quad \text{Equation 7}$$

Cancer risks are calculated separately for each carcinogen and each exposure pathway, and the resulting risks are summed to yield a total upperbound estimate of cancer risk due to multiple exposures. This is a conservative approach that can result in an artificially elevated estimate of cancer risk, especially if several carcinogens are present. This is because 95th percentile estimates may not be strictly additive (EPA 1989c). RME cancer risks are likely to be overestimated significantly because they are calculated by multiplying together 95th percentile estimates of cancer potency and reasonable maximum estimates of concentration and exposure. The approach also ignores potential antagonistic or synergistic effects.

EPA policy must be considered in order to interpret the significance of the cancer risk estimates. In the National Oil and Hazardous Substances Pollution Contingency Plan (EPA 1990c), EPA states that: "For known or suspected carcinogens, acceptable exposure levels are generally concentration levels that represent an excess upper-bound lifetime cancer risk to an individual of between 1×10^{-4} and 1×10^{-6}." These values are equivalent to a 1 in 10,000 to 1 in 1,000,000 chance of getting cancer from the exposure. These risk levels are extremely low and would not be measurable or discernible in individuals or even in a large population. For example, a risk level of 1 in 10,000 (1×10^{-4}) would increase an individual's chance of getting cancer from the background risk of 1 in 3 to 1.0001 in 3. EPA guidance further states that: "where the cumulative carcinogenic risk to an individual based on reasonable maximum exposure for both current and future land use is less than 10^{-4}, and the noncarcinogenic hazard quotient is less than 1.0, action is generally not warranted..." (EPA 1991b). The Guidance on Risk Characterization for Risk Managers and Risk Assessors (EPA 1992b) and the RCRA Subpart S proposed rules (EPA 1990a) concur with the 1×10^{-6} to 1×10^{-4} target risk range. The results of the baseline risk assessment for groundwater at the UPRR Omaha Shops are presented in the following sections.

B.7 SITE RISKS

Chemical intake was combined with chemical-specific toxicity values to obtain an estimate of health risk. Noncarcinogenic hazards and carcinogenic risks to construction workers, were estimated for all relevant exposure routes and COCs using the approach and exposure assumptions described above. Tables A-10 through A-12 present the calculated construction worker risks via ingestion, dermal contact, and inhalation of volatile emissions at the site. Table A-13 summarizes the results of the risk assessment.

The total hazard index calculated for noncarcinogenic health effects due to subchronic exposures to COCs in groundwater via the dermal contact, inhalation, and ingestion pathways is 49. This HI exceeds 1.0, which indicates that the potential for adverse noncarcinogenic health effects exists. However, the magnitude by which the calculated HI exceeds 1.0 is not directly correlated to the magnitude of possible adverse health effects. Incidental ingestion of #2 fuel oil in groundwater is the primary contributor to the HI estimate. The estimate is driven solely by a single detection of 25,000 mg/L of #2 fuel oil in the sump at the Stores Building. The HI risk is probably significantly overestimated for this exposure because a construction worker at the Omaha Shops site would not be exposed for the duration of a construction project only to the sump, which is confined to the south end of the Stores Building basement. Furthermore, the Stores Building and basement have been removed and no longer provide a direct exposure route to the groundwater in the sump.

Potential adverse health effects across the site due to ingestion of groundwater are, therefore, likely to be significantly less than the calculated HI.

The estimated lifetime excess cancer risk under the assumed subchronic exposure conditions is 3×10^{-6}. This level is within the EPA target risk range 1×10^{-6} to 1×10^{-4} for exposure to chemicals released from hazardous waste sites (EPA 1990a; 1991b; 1992b).

Qualitative Assessment of Exposure to 2-Methylnaphthalene

2-Methylnaphthalene is a PAH considered to be toxic by all exposure routes (inhalation, ingestion, and dermal contact). However, 2-methylnaphthalene is not classifiable as to carcinogenicity, i.e., it is assigned to Class D in IRIS (1995). There is no provisional RfD for 2-methylnaphthalene (Dollarhide 1992). The report initially suggested that due to a lack of suitable data for deriving toxicity values for 2-methylnaphthalene, that naphthalene values be used as surrogates. However, further reported investigation revealed uncertainties were considered too great to recommend adoption of this approach. Nevertheless, if the subchronic RfD for naphthalene (4E-02 mg/kg-day, adjusted for dermal absorption to 2E-02) were used, a hazard quotient for construction workers can be calculated.

2-Methylnaphthalene was detected in groundwater at a maximum concentration of 35.21 μg/L. Assuming highest exposed receptor pathway (dermal contact, 3.96E-02) and adjusting the maximum detected concentration for dermal absorption (Kp = 6.9E-02), the estimated hazard quotient would be 0.005. This is well below the target level of 1.0 and the highest hazard index for construction workers at the Omaha Shops (0.14 for dermal contact, Table A-13). Therefore, the underestimation of potential risk from the exclusion of 2-methylnaphthalene from the quantitative risk assessment is not likely to affect the conclusions of the risk assessment.

Qualitative Assessment of Lead

Lead exposures are not evaluated quantitatively in the risk assessment because EPA withdrew the RfD for lead in 1989, primarily due to the lack of discernible threshold dose and the numerous sources of lead in the environment. The maximum detected concentration of lead in groundwater across the site was 0.16 mg/L, which exceeds the action level for drinking water of 0.015 (EPA 1995). However, it is important to note that the action level for drinking water and the groundwater at the Omaha Shops is unlikely to be used for domestic purposes. Therefore, it is unlikely that the exclusion of lead from the quantitative risk assessment would affect the conclusions of the risk assessment.

B.8 UNCERTAINTIES AND LIMITATIONS

Throughout the human health risk assessment, conservative assumptions were used that probably overestimate actual risks at the site. Although some uncertainties may exist that may underestimate risk, the overall conservative features of the risk assessment process are likely to compensate for them and hold an upperbound estimate of potential risk. The important factors that tend to over- or underestimate risk are discussed below.

B.8.1 Factors That Tend to Overestimate Risk

- No source decay of organic compounds in soil was assumed to occur over a 1-year period. This assumption is likely to result in overestimation of exposure point concentrations and risks due to inhalation of volatile compounds, dermal contact, and soil ingestion, perhaps by several times.

- EPA RfDs are based on conservative estimates of the potential for adverse noncarcinogenic effects. Most RfDs are developed by reducing the dose at which no adverse effects were observed in the most sensitive animal species by uncertainty factors ranging from 10 to 1,000. This extrapolation method provides a considerable level of conservatism in the RfDs used to estimate the potential for noncarcinogenic health effects and could result in an overestimate of potential hazards by one or more orders of magnitude.

- EPA slope factors are highly conservative estimates of dose-response relationships and probably result in a significant overstatement of actual cancer risk. Cancer SFs are calculated using the 95 percent UCL on a dose-response curve estimated by a linear mathematical model that extrapolates from short-term, high dose animal exposures to long-term, low-dose human exposures. EPA guidance states that the cancer SFs are upperbound estimates of potency, and actual potency is likely to be lower.

- The assumption that the effects of exposure to multiple noncarcinogens are additive may result in an overestimate of health hazard. This approach neglects the fact that different toxicants may have different mechanisms of action and different target organ specificities and that their effects are not necessarily additive. The assumption that risks for carcinogens are additive may similarly lead to an overestimate of carcinogenic risk.

- RME cancer risks are estimated by multiplying together a series of upper 95th percentile estimates of carcinogenicity, concentration, and exposure factors. This practice can result in a significant overestimate of potential risk.

B.8.2 Factors That Tend to Underestimate Risk

- A few potential COCs were not evaluated in the quantitative risk assessments because they do not have EPA-established toxicity factors. For example, 1,2-dichloroethene does not have inhalation toxicity factors; therefore, this uptake route was not evaluated quantitatively. EPA has established toxicity factors for hundreds of potentially hazardous compounds associated with waste materials, and detected analytes. Compounds without toxicity factors often have no known adverse affects or data are inadequate for quantitative risk assessment. In this risk assessment, detected chemicals without EPA-established toxicity factors include lead, 2-methylnaphthalene, and delta-BHC. Results of available experimental studies give no indication that these chemicals are significantly more toxic than those chemicals detected which have EPA-established toxicity factors. Therefore, the exclusion of these chemicals from the quantitative analysis is not likely to affect the conclusions of the risk assessment relative to the chemicals with known toxicities detected at the site.

B.8.3 Factors That May Over- or Underestimate Risk

- Rates of water ingestion, body surface area exposure, exposure time, etc., are selected to estimate "reasonable maximum" rates. The values may overestimate or underestimate actual rates. However, values used in the RME scenario are selected to provide an upperbound estimate of the maximum exposure (and risk) that could reasonably be expected to occur at this site.

- Cumulative noncarcinogenic and carcinogenic health risks are estimated assuming that effects of individual chemicals are additive. This approach does not account for potential synergism, or differences in target-organ specificity and mechanism of action. The approach may over- or underestimate actual health risks.

- Many of the air or groundwater model parameters, such as K_{ow}'s, mass transfer rates, Henry's constants, and bioconcentration factors, were determined either during controlled experimental conditions or equilibrium conditions. These parameters may overestimate or underestimate the actual value in the natural environment which would also over- or underestimate the quantitative risk calculations.

B.9 SUMMARY AND CONCLUSIONS

The risk assessment for groundwater at the Omaha Shops considered one receptor population. Construction workers were assumed to be exposed to groundwater via ingestion, dermal contact, and inhalation pathways. The noncarcinogenic hazard index for construction receptors exceeds 1.0, but the cancer risk for all receptors is within EPA's target risk range. The noncarcinogenic hazard index is probably significantly overestimated for the site, since the estimate is driven by a single high detection of #2 fuel oil at the sump in the basement of the Stores Building. The Stores Building has been removed and no longer provides a direct exposure route to the groundwater in the sump. Potential adverse health effects across the site due to ingestion of groundwater are, therefore, likely to be significantly less than the calculated HI.

B.10 LIST OF ABBREVIATIONS

GENERAL ABBREVIATIONS

AT	Averaging Time
ATSDR	Agency for Toxic Substances and Disease Registry
BKG	Background
BW	Body Weight
COC	Chemical of Concern
ED	Exposure Duration
EF	Exposure Frequency
EPA	Environmental Protection Agency
FC	Fraction ingested from contaminated source
GW	Groundwater
HEAST	Health Effects Assessment Summary Tables
HQ	Hazard Quotient
HSDB	Hazardous Substances Data Bank
IF	Intake Factor
IR	Intake Rate
IRIS	Integrated Risk Information System
LOAEL	Lowest observed adverse effects
max	Maximum
min	Minimum
MW	Monitoring well
NA	Not available
NOAEL	No observed adverse effects level
OSWER	Office of Solid Waste and Emergency Response
PAH	Polycyclic aromatic hydrocarbon
PC	Permeability Coefficient
PCB(s)	Polychlorinated biphenyl(s)
RCRA	Resource Conservation and Recovery Act
RfD	Reference dose
RfC	Reference concentration
RME	Reasonable maximum exposure

SA	Surface Area
SDEF	Standard Default Exposure Factors
SF	Slope factor
SVOC(s)	Semivolatile organic compound(s)
TPH	Total Petroleum Hydrocarbons
UPRR Omaha Shops	Union Pacific Railroad Omaha Shops and Maintenance Facility Site
USEPA	United States Environmental Protection Agency
VOC(s)	Volatile organic compound(s)
W-C	Woodward-Clyde

UNITARY ABBREVIATIONS

ATM	atmospheres
atm-m^3/mole	atmospheres-cubic meters per mole
cfs	cubic feet per second
cm	centimeter
sm/sec	centimeters per second
cm^2	square centimeter
cm^2/day	square centimeters per day
cm^3	cubic centimeter
d	day
ft	feet
ft^2	square feet
ft/day	feet per day
g	gram
hr	hour
hrs/day	hours per day
hrs/workday	hours per workday
kg	kilogram
kg/kg-day	kilograms per kilogram per day
kg/mg	kilograms per milligram
L	liter
m	meter
m^2	square meter

m^3	cubic meter
m/hr	meters per hour
m/sec	meters per second
mg	milligram
mg/cm^3	milligram per cubic centimeter
mg/day	milligrams per day
mg/kg	milligrams per kilograms
mg/kg-day or mg/kg/day	milligrams per kilogram per day
mg/L	milligrams per liter
ml	milliliter
mm-Hg	millimeters of mercury
m^3/day	cubic meters per day
m^3/hr	cubic meters per hour
m^3/kg-day	cubic meters per kilogram per day
ppb	parts per billion
ppm	parts per million
s	second
μg/kg	micrograms per kilograms
μg/L	micrograms per liter
$\mu g/m^3$	micrograms per cubic meter
yr or y	year

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TABLE B-1

CHEMICALS OF CONCERN IN GROUNDWATER AT UP OMAHA SHOPS

Metals	SVOCs
Arsenic	Di-n-butylphthalate
Beryllium	2-Methylnaphthalene*
Cadmium	
Chromium	
Copper	
Lead*	
Mercury	
Nickel	
Selenium	
Zinc	
VOCs	**Pesticides/PCBs**
1,1-Dichloroethene	4,4-DDE
1,2-Dichloroethene (total)	4,4-DDT
4-Methyl-2-pentanone (Methyl isobutyl ketone [MIBK])	alpha-BHC (alpha-Benzenehexachloride or alpha-Lindane)
Benzene	beta-BHC
Chlorobenzene	delta-BHC*
Tetrachloroethene	gamma-BHC
Toluene	alpha-Chlordane
Trichloroethene	gamma-Chlordane
	Aldrin
Petroleum Hydrocarbons	Dieldrin
as #2 fuel oil	Endosulfan
as #2 diesel	Endosulfan I
as gasoline	Heptachlor
	Aroclor 1016
	Aroclor 1221
	Aroclor 1232
	Aroclor 1242

* These chemicals do not have EPA-established toxicity factors, therefore, they were addressed qualitatively in the risk assessment.

TABLE B-2

SUMMARY OF CONCENTRATIONS OF CHEMICALS OF CONCERN IN GROUNDWATER AT UP OMAHA SHOPS

	Groundwater Concentrations RME (mg/L)
Metals	
Arsenic	0.16
Beryllium	0.0008
Cadmium	0.002
Chromium	0.008
Copper	0.04
Mercury	0.005
Nickel	1.15
Selenium	0.042
Zinc	0.6
SVOCs	
Di-n-butylphthalate	0.00467
VOCs	
1,1-Dichloroethene	0.02994
1,2-Dichloroethene (total)	0.734
4-Methyl-2-pentanone (MIBK)	0.01771
Benzene	0.00372
Chlorobenzene	0.19191
Tetrachloroethene	0.441
Toluene	0.04229
Trichloroethene	0.1386
Pesticides/PCBs	
4,4'-DDE	0.000123
4,4'-DDT	0.000354
alpha-BHC (Lindane)	0.000957
beta-BHC	0.00415
gamma-BHC	0.0014
alpha-Chlordane	0.001057
gamma-Chlordane	0.000687
Aldrin	0.001167
Dieldrin	0.00017
Endosulfan	0.000215
Endosulfan I	0.000037
Heptachlor	0.00415
Aroclor 1016	0.000177
Aroclor 1221	0.00207
Aroclor 1232	0.0101
Aroclor 1242	0.000874
Petroleum Hydrocarbons	
as #2 fuel oil	25,000
as #2 diesel	5.93
as gasoline	0.06

RME = Maximum detected concentration

TABLE B-3

CONCENTRATIONS OF CHEMICALS OF CONCERN ADJUSTED FOR DERMAL ABSORPTION IN GROUNDWATER AT UP OMAHA SHOPS

	Groundwater Concentrations RME (mg/L)	Dermal PC[1] (cm/hr)	Dermal Adjusted Concentration RME (mg/L)
Metals			
Arsenic	0.16	0.001	1.60E-04
Beryllium	0.0008	0.001	8.00E-07
Cadmium	0.002	0.001	2.00E-06
Chromium	0.008	0.001	8.00E-06
Copper	0.04	0.001	4.00E-05
Mercury	0.005	0.001	5.00E-06
Nickel	1.15	0.001	1.15E-03
Selenium	0.042	0.001	4.20E-05
Zinc	0.60	0.001	6.00E-04
SVOCs			
Di-n-butylphthalate	0.00467	0.033	1.54E-04
VOCs			
1,1-Dichloroethene	0.02994	0.016	4.79E-04
1,2-Dichloroethene (total)	0.734	0.01	7.34E-03
4-Methyl-2-pentanone (MIBK)	0.01771	NA	
Benzene	0.00372	0.021	7.81E-05
Chlorobenzene	0.19191	0.041	7.87E-03
Tetrachloroethene	0.441	0.048	2.12E-02
Toluene	0.04229	0.045	1.90E-03
Trichloroethene	0.1386	0.016	2.22E-03
Pesticides/PCBs			
4,4'-DDE	0.000123	0.24	2.95E-05
4,4'-DDT	0.000354	0.43	1.52E-04
alpha-BHC (Lindane)	0.000957	0.014	1.34E-05
beta-BHC	0.004150	0.014	5.81E-05
gamma-BHC	0.001400	0.014	1.96E-05
alpha-Chlordane	0.001057	0.052	5.50E-05
gamma-Chlordane	0.000687	0.052	3.57E-05
Aldrin	0.001167	0.0016	1.87E-06
Dieldrin	0.000170	0.016	2.72E-06
Endosulfan	0.000215	NA	
Endosulfan I	0.000037	NA	
Heptachlor	0.004150	0.011	4.57E-05
Aroclor 1016	0.000177	0.032	5.66E-06
Aroclor 1221	0.002070	0.032	6.62E-05
Aroclor 1232	0.010100	0.032	3.23E-04
Aroclor 1242	0.000874	0.032	2.80E-05
Petroleum Hydrocarbons			
as #2 fuel oil	25,000	NA	
as #2 diesel	5.93	NA	
as gasoline	0.06	NA	

[1] PC = Permeability coefficient from EPA 1992a
RME = Maximum detected concentration
Dermal Adjusted Concentration = RME * PC
RME concentrations from Table A-2
NA = Not available

TABLE B-4

AIR CONCENTRATIONS OF VOLATILE CONSTITUENTS OF CONCERN IN GROUNDWATER AT UP OMAHA SHOPS

	R (atm-m^3/mol-K)	T (K)	H (atm-m^3/mol)	kl (cm/hr)	kg (cm/hr)	Kl (cm/hr)	Cw (mg/cm^3)	Fa (mg/hr/cm^2)	A(cm^2)	Q (mg/hr)	LS (m)	V (m/hr)	MH (m)	Ca (mg/m^3)
1,1-Dichloroethene	8.20E-05	293	3.40E-02	13	1293	1.09E-03	2.99E-05	3.28E-08	7.50E+05	2.46E-02	5	3600	2	6.83E-07
1,2-Dichloroethene (total)	8.20E-05	293	5.59E-03	27	2180	1.07E-04	7.34E-04	7.83E-08	7.50E+05	5.88E-02	5	3600	2	1.63E-06
4-Methyl-2-pentanone (MIBK)	8.20E-05	293	2.59E-02	17	1450	7.43E-04	1.77E-05	1.32E-08	7.50E+05	9.87E-03	5	3600	2	2.74E-07
Benzene	8.20E-05	293	6.74E-03	25	2010	1.40E-04	3.72E-06	5.19E-10	7.50E+05	3.89E-04	5	3600	2	1.08E-08
Chlorobenzene	8.20E-05	293	3.72E-03	22	1820	8.51E-05	1.92E-04	1.63E-08	7.50E+05	1.22E-02	5	3600	2	3.40E-07
Tetrachloroethene	8.20E-05	293	2.59E-02	17	1450	7.43E-04	4.41E-04	3.28E-07	7.50E+05	2.46E-01	5	3600	2	6.83E-06
Toluene	8.20E-05	293	6.74E-03	25	2010	1.40E-04	4.23E-05	5.90E-09	7.50E+05	4.43E-03	5	3600	2	1.23E-07
Trichloroethene	8.20E-05	293	9.10E-03	21	1700	2.23E-04	1.39E-04	3.09E-08	7.50E+05	2.32E-02	5	3600	2	6.43E-07

R = gas constant = 8.2E-05 atm-m3/mol-K
T = absolute temperature (equivalent to 20°C)
H = Henry's Law Constant (Lyman et al. 1990; Howard 1990a, 1990b, 1991); chemical specific
kl = liquid phase mass transfer coefficient (Lyman et al. 1990); chemical specific
kg = gas phase mass transfer coefficient (Lyman et al. 1990); chemical specific
Kl = overall mass transfer coefficient (Kl = 1/((l/kl)+(R*T/H*kg)))
Cw = concentration of chemical in water (from Table A-2) x 0.001
Fa = mass flux to atmosphere (Fa = Kl*Cw)
Q = emission rate of vapors (Q = Fa*area)
A = Estimated area of a trench
LS = equivalent side length of site perpendicular to wind direction
V = average wind velocity estimate in the breathing zone of a construction trench (1 m/sec)
MH = mixing height (default value EPA 1991b)
Ca = RME concentrations of compound in air (Ca = Q/(LS*V*MH))

Note: Only COCs with inhalation toxicity factors appear in the table.

TABLE B-5

GROUNDWATER INGESTION INTAKE ASSUMPTIONS (CONSTRUCTION WORKER)

$$\text{Intake Factor} = \frac{IR \times FC \times EF \times ED \times CF}{BW \times AT}$$

Parameter	Reasonable Maximum
IR: Ingestion Rate (ml/day)[1]	10
FC: Fraction ingested from contaminated source[2]	1
EF: Exposure frequency (days/year)[3]	40
ED: Exposure duration (years)[4]	1
CF: Conversion factor (L/ml)	1E-03
BW: Body weight (kg)[5]	70
AT: Average time (days)[6]	
Noncarcinogenic	365
Carcinogenic	25,550
Intake Factor (L/kg-day)	
Noncarcinogenic	1.57E-05
Carcinogenic	2.24E-07

1. IR: Estimated accidental water ingested while working on a construction project where excavation has caused groundwater to discharge to the surface. In this scenario, groundwater is assumed to be accidentally ingested from the construction workers hands and not from actual standing water.
2. FC: Value assumes that all the groundwater is ingested in an eight-hour day is from the construction area.
3. EF: Estimated duration of construction activities: two months (8 weeks)
4. ED: Construction activities are assumed to be completed within one year.
5. BW: The average adult body weight is 70 kg (EPA 1989b)
6. AT: ED x 365 days/year for noncarcinogens; 70 years x 365 days/year for carcinogens.

TABLE B-6

DERMAL CONTACT WITH GROUNDWATER INTAKE ASSUMPTIONS (CONSTRUCTION WORKER)

$$\text{Intake Factor} = \frac{\text{SA x PCx ETx EF x ED x CF}}{\text{BW x AT}}$$

Parameter	Reasonable Maximum
SA: Surface Area (cm^2)[1]	3,160
PC: Permeability Constant (cm/hr)[2]	Chemical specific
ET: Exposure Time (hours/day)[3]	8
EF: Exposure frequency (days/year)[4]	40
ED: Exposure duration (years)[5]	1
CF: Conversion factor (L/cm^3)	1E-03
BW: Body weight (kg)[6]	70
AT: Average time (days)[7]	
Noncarcinogenic	365
Carcinogenic	25,550
Intake Factor (kg/kg-day)	
Noncarcinogenic	3.96E-02
Carcinogenic	5.65E-04

1. SA: The worker is assumed to wear a uniform or civilian clothing appropriate for maintenance or other outdoor work. RME surface area (3,160 cm^2) is equivalent to head, forearms, and hands (EPA 1989b).
2. PC: Chemical-specific absorbed fractions are given in Table 5.6-10a. They are used to adjust chemical concentrations for use in calculating risks for the dermal contact route. The intake factors shown here are calculated using PC = 1.0.
3. ET: The value of 1.0 assumes that the construction worker spends an eight hour day working at UPRR Omaha Shops.
4. EF: Estimated duration of construction activities: two months (8 weeks).
5. ED: Construction activities are assumed to be completed within one year.
6. BW: The average adult body weight is 70 kg (EPA 1989b).
7. AT: ED x 365 days/year for noncarcinogens; 70 years x 365 days/year for carcinogens.

TABLE B-7

INHALATION INTAKE ASSUMPTIONS (CONSTRUCTION WORKER)

$$\text{Intake Factor} = \frac{IR \times ET \times EF \times ED}{BW \times AT}$$

	Parameter	Reasonable Maximum
IR:	Inhalation Rate (m^3/hr)[1]	2.5
ET:	Exposure time (hrs/day)[2]	8
EF:	Exposure frequency (days/year)[3]	40
ED:	Exposure duration (years)[4]	1
BW:	Body weight (kg)[5]	70
AT:	Average time (days)[6]	
	Noncarcinogenic	365
	Carcinogenic	25,550
Intake Factor (m^3/kg-day)		
	Noncarcinogenic	3.13E-02
	Carcinogenic	4.47E-04

1. IR: Rate is standard default exposure factor (SDEF) (EPA 1991a)
2. ET: The value of 1.0 assumes that the construction worker spends an eight hour day working at UPRR Omaha Shops.
3. EF: Estimated duration of construction earth-moving activities.
4. ED: Construction activities are assumed to be compled within two months.
5. BW: The average adult body weight is 70 kg (EPA 1989b).
6. AT: ED x 365 days/year for noncarcinogens; 70 years x 365 days/year for carcinogens.

TABLE B-8
REFERENCE DOSES FOR NONCARCINOGENIC CHEMICALS OF CONCERN

Chemical	Noncarcinogenic RfD (mg/kg/d)				Uncertainty Factor		Confidence Level	Critical Effect	Species/Experiment Length/Target Organ
	Inhalation	Source	Oral	Source	Inhal	Oral			
Aldrin								Liver toxicity	Rat, 0.025 mg/kg/d for 2 years; liver
Chronic	ND		3×10^{-5}	1	NA	1000	Medium		
Arsenic (Inorganic)							Medium	Skin keratosis and hyperpigmentation, possible vascular complications	Human, 0.009 mg/L oral; skin.
Subchronic	ND		3×10^{-4}	2	NA	3			
Chronic*	ND		3×10^{-4}	1	NA	3			
Beryllium							Low	None observed	Rat, 0.54 mg/kg/d, oral drinking water, lifetime.
Subchronic	ND		5×10^{-3}	2	NA	100			
Chronic*	ND		5×10^{-3}	1	NA	100			
Cadmium							High	Kidney damage, significant proteinuria	Human, 0.055 mg/kg/d - water, 0.01 mg/kg/d - food; chronic exposure, kidney.
Subchronic	ND		ND		NA				
Chronic*	ND		5×10^{-4} (water)	1	NA	10			
			1×10^{-3} (food)	1		10			
Chlordane							Low	Regional liver hypertrophy in females	Rat, 0.055 mg/kg/d, oral 30 months; liver.
Subchronic	ND		6×10^{-5}	2	NA	1000			
Chronic*	ND		6×10^{-5}	1	NA	1000			
Chlorobenzene							Medium	Histopathologic changes in the liver	Dog, 19.5 mg/kg/d, oral 13 weeks; liver
Subchronic	5×10^{-2}	8	2×10^{-1}	3	1000	100			
Chronic	5×10^{-3}	4	2×10^{-2}	1	10000	1000			
Chromium III							Low	None observed	Rat, 5% diet, 840 days
Subchronic	ND	5	1×10^{1}	2	NA	1000			
Chronic	ND	5	1×10^{0}	1	NA	1000			
Chromium VI							Low	None observed	Rate, 2.4 mg/kg/day, drinking water, 1 year
Subchronic	ND	5	2×10^{-2}	2	NA	100			
Chronic*	ND	5	5×10^{-3}	1	NA	500			

*See Slope Factors table
ND=No data
NA = Not applicable
1 Verifiable in IRIS
2HEAST 1994 and supplements
3 HEAST 1993 and supplements
4 HEAST 1993 - Value derived from methodology not current with that used by the RfD/RfC workgroup (see Table 2 in HEAST 1993)
5 HEAST 1993 - Chronic RfC considered not verifiable (12/11/91) by the RfD/RfC workgroup
6 Withdrawn from IRIS. Under review
7 HEAST 1992 - Supplement No. 2 (11/92)
8 HEAST 1992 - Value derived from methodology not current with that used by the RfD/RfC workgroup (see Table 2 in HEAST 1992)
9 HEAST 1994 - Converted from 1.3 mg/L
10 Provisional RfD for diesel fuel was used for #2 fuel oil.

TABLE B-8
REFERENCE DOSES FOR NONCARCINOGENIC CHEMICALS OF CONCERN

Chemical	Noncarcinogenic RfD (mg/kg/d) Inhalation	Source	Oral	Source	Uncertainty Factor Inhal	Oral	Confidence Level	Critical Effect	Species/Experiment Length/Target Organ
Copper							Low	Intestinal irritation	Human, 5.3 mg oral, single dose; gastrointestinal system.
Subchronic	ND		3.7×10^{-2}	9	NA				
Chronic	ND		3.7×10^{-2}	9	NA				
4,4-DDT							Medium	Liver lesions	Rats, 0.05 mg/kg/d oral, 27 weeks; liver.
Subchronic	ND		5×10^{-4}	2	NA	100			
Chronic*	ND		5×10^{-4}	1	NA	100			
1,1-Dichloroethene								Liver lesions	Rat, 9 mg/kg/d oral drinking water, 2 years; liver.
Subchronic	ND		9×10^{-3}	2		1000			
Chronic*	ND		9×10^{-3}	1		1000			
cis-1,2-Dichloroethene								Blood - decreased hematocrit and hemoglobin	Rat, 32 mg/kg/d oral gavage, 90 days; blood.
Subchronic	ND		1×10^{-1}	2		300			
Chronic	ND		1×10^{-2}	2		3000			
trans-1,2-Dichloroethene							Low	Blood - increased serum alkaline phosphatase in males	Mouse, 17 mg/kg/d oral drinking water, 90 days, blood.
Subchronic	ND		2×10^{-1}	2	NA	100			
Chronic	ND		2×10^{-2}	1	NA	1000			
Dieldrin							Medium	Liver lesions	Rat, 0.005 mg/kg/d diet, 2 years; liver.
Subchronic	ND		5×10^{-5}	2	NA	100			
Chronic*	ND		5×10^{-5}	1	NA	100			
Diesel Fuel (1)								Fatty changes in liver, hyaline droplet nephropathy	Mouse, 50 mg/m^3, inhalation; kidney, liver
Chronic	ND		8×10^{-3}	7	NA	10,000	Medium		
Di-n-butylphthalate							Low	Increased mortality; fetotoxicity, degeneration of seminiferous tubules	Rat, 125 mg/kg/day, oral, 52 weeks, whole body
Subchronic	ND		1×10^{0}	2	NA				
Chronic	ND	2	1×10^{-1}	1	NA	1000			Mice, 2100 mg/kg/day, oral, throughout gestation.
Gasoline (unleaded)							Low	CNS effects, hyaline droplet nephropathy	Rat and mouse, 230 mg/m^3 for 3-6 mo.; kidney.
Chronic*	ND		2×10^{-1}	7	NA				

*See Slope Factors table
ND=No data
NA = Not applicable
1 Verifiable in IRIS
2HEAST 1994 and supplements
3 HEAST 1993 and supplements
4 HEAST 1993 - Value derived from methodology not current with that used by the RfD/RfC workgroup (see Table 2 in HEAST 1993)
5 HEAST 1993 - Chronic RfC considered not verifiable (12/11/91) by the RfD/RfC workgroup
6 Withdrawn from IRIS. Under review
7 HEAST 1992 - Supplement No. 2 (11/92)
8 HEAST 1992 - Value derived from methodology not current with that used by the RfD/RfC workgroup (see Table 2 in HEAST 1992)
9 HEAST 1994 - Converted from 1.3 mg/L
10 Provisional RfD for diesel fuel was used for #2 fuel oil.

TABLE B-8
REFERENCE DOSES FOR NONCARCINOGENIC CHEMICALS OF CONCERN

Chemical	Noncarcinogenic RfD (mg/kg/d)				Uncertainty Factor		Confidence Level	Critical Effect	Species/Experiment Length/Target Organ
	Inhalation	Source	Oral	Source	Inhal	Oral			
Heptachlor							Low	Increased (males) weight of liver	Rat, 0.15 mg/kg/d diet, 2 years; liver.
Subchronic	ND		5×10^{-4}	2	NA	300			
Chronic*	ND		5×10^{-4}	1	NA	300			
gamma-Hexachlorocyclohexane (BHC)								Liver and kidney toxicity	Rats, varying amounts, diet, 12 weeks, liver and kidney.
Subchronic	ND		3×10^{-3}	2	NA	100			
Chronic*	ND	3	3×10^{-4}	1	NA	1000			
Lead							Low	Altered blood enzyme levels; altered neurobehavioral development - children	
Subchronic					NA	NA			
Chronic*					NA	NA			
Mercury							Low	Neurotoxicity. Kidney effects	Human, 0.009 mg/m^3, intermittent inhalation, nervous system; Rat, parenteral, kidney.
Subchronic	8.6×10^{-5}	2	3×10^{-4}	2	30	1000			
Chronic	8.6×10^{-5}	2,6	3×10^{-4}	2,6	30	1000			
Methyl isobutyl ketone								Liver and kidney	Rat, 50 mg/kg/d, gavage, 13 weeks; rat, 50 ppm, intermittent inhalation, 90 days.
Subchronic	2×10^{-1}	4	5×10^{-1}	2		100			
Chronic	2×10^{-2}	4	5×10^{-2}	2		1000			
Nickel							Medium	Decreased body and organ weight	Rat, 100 ppm, diet 2 years; whole body, major organs.
Subchronic	ND		2×10^{-2}	2	NA	300			
Chronic	ND		2×10^{-2}	1	NA	300			
Selenium								Clinical selenosis	Human, 0.853 mg/d diet; whole body.
Subchronic	ND		5×10^{-3}	2		3			
Chronic	ND		5×10^{-3}	1					
Tetrachloroethene							Low	Hepatotoxicity, increased liver weight	Rats, mice, 100-1000 mg/kg/d, oral, gavage, 6 weeks.
Subchronic	ND		1×10^{-1}	2	NA	100			
Chronic	ND		1×10^{-2}	1	NA	1000			

*See Slope Factors table
ND=No data
NA = Not applicable
1 Verifiable in IRIS
2HEAST 1994 and supplements
3 HEAST 1993 and supplements
4 HEAST 1993 - Value derived from methodology not current with that used by the RfD/RfC workgroup (see Table 2 in HEAST 1993)
5 HEAST 1993 - Chronic RfC considered not verifiable (12/11/91) by the RfD/RfC workgroup
6 Withdrawn from IRIS. Under review
7 HEAST 1992 - Supplement No. 2 (11/92)
8 HEAST 1992 - Value derived from methodology not current with that used by the RfD/RfC workgroup (see Table 2 in HEAST 1992)
9 HEAST 1994 - Converted from 1.3 mg/L
10 Provisional RfD for diesel fuel was used for #2 fuel oil.

TABLE B-8
REFERENCE DOSES FOR NONCARCINOGENIC CHEMICALS OF CONCERN

Chemical	Noncarcinogenic RfD (mg/kg/d)				Uncertainty Factor		Confidence Level	Critical Effect	Species/Experiment Length/Target Organ
	Inhalation	Source	Oral	Source	Inhal	Oral			
Toluene							Medium	Liver/kidney altered weight; CNS neurological effects; eyes/nose irritation	Rats, 223 mg/kg/d oral gavage, 13 weeks, liver, kidney; human, 40 ppm inhalation; human, 80 ppm, inhalation, CNS, eyes, nose
Subchronic	1.1×10^{-1}	7	2×10^{0}	2	300	100			
Chronic	1.1×10^{-1}	1	2×10^{-1}	1	300	1000			
Vanadium							-	None observed	Rat, 5 ppm, drinking H_2O, lifetime.
Subchronic	ND		7×10^{-3}	2	NA	100			
Chronic	ND		7×10^{-3}	2	NA	100			
Zinc (metallic)							Medium	Anemia	Human, 2.14 mg/kg/d, oral, blood.
Subchronic	ND		3×10^{-1}	7	NA	3			
Chronic	ND		3×10^{-1}	1	NA	3			

*See Slope Factors table
ND=No data
NA = Not applicable
1 Verifiable in IRIS
2HEAST 1994 and supplements
3 HEAST 1993 and supplements
4 HEAST 1993 - Value derived from methodology not current with that used by the RfD/RfC workgroup (see Table 2 in HEAST 1993)
5 HEAST 1993 - Chronic RfC considered not verifiable (12/11/91) by the RfD/RfC workgroup
6 Withdrawn from IRIS. Under review
7 HEAST 1992 - Supplement No. 2 (11/92)
8 HEAST 1992 - Value derived from methodology not current with that used by the RfD/RfC workgroup (see Table 2 in HEAST 1992)
9 HEAST 1994 - Converted from 1.3 mg/L
10 Provisional RfD for diesel fuel was used for #2 fuel oil.

TABLE B-9
SLOPE FACTORS FOR CARCINOGENIC CHEMICALS OF CONCERN

Chemical	Carcinogenic Slope Factor (mg/kg-d)$^{-1}$ Inhalation	Source	Oral	Source	EPA Class	Critical Effect	Species/Experiment Length/Target Organs
Arsenic (inorganic)	1.5×10^{1}	6	1.75×10^{0}	6	A	Lung cancer; skin cancer	Human, inhalation, occupational, respiratory system; human, oral, skin
Benzene	2.9×10^{-2}	1	2.9×10^{-2}	1	A	Leukemia (nonlymphocytic)	Human, inhalation, occupational; blood
Beryllium	8.4×10^{0}	1	4.3×10^{0}	1	B2	Lung cancer	Human, inhalation, occupational; lungs
alpha-BHC			6.3×10^{0}	1	B2	Liver carcinoma	Mouse, drinking water, 24 weeks; liver
beta-BHC	1.8×10^{0}	1	1.8×10^{0}	1	C	Liver neoplasia	Mouse, diet, 110 weeks; liver
gamma-BHC (lindane)			1.3×10^{0}	1	B2-C	Liver neoplasia	Mouse, diet, 110 weeks; liver
Cadmium	6.1×10^{0}	1	ND		B1	Respiratory system neoplasia	Human, inhalation, occupational; respiratory system
Chlordane	1.3×10^{0}	1	1.3×10^{0}	1	B2	Carcinoma	Mouse, oral, diet; liver
Chromium (VI)	41	2	ND		A	Respiratory system neoplasia	Human, inhalation, occupational; respiratory system
4,4-DDE	ND		3.4×10^{-1}	1	B2	Thyroid and liver carcinoma, neoplasia	Mouse, rat, hamsters, oral; thyroid, liver
4,4-DDT	3.4×10^{-1}	1	3.4×10^{-1}	1	B2	Neoplasia	Mouse, rat, diet; liver
1,1-Dichloroethene	1.75×10^{-1}	1	6×10^{-1}	1	C	Adenocarcinoma	Mouse, inhalation, 12 months; kidney
Dieldrin	1.6×10^{1}	1,2	1.6×10^{1}	1	B2	Hepatocellular carcinoma	Mouse, diet; liver
Gasoline	ND		1.7×10^{-3}	5	C	Kidney and liver neoplasms	Mouse, inhjalation; liver, kidney and skin
Heptachlor	4.5	1	4.5	1	B2	Hepatocellular carcinoma	Mouse, diet; liver
Lead (inorganic)	ND		ND	1	B2	Bilateral renal carcinoma	Rats, diet; kidney
Nickel	8.4×10^{-1}	2			C	Respiratory system tumors	Human, occupational; respiratory system
PCB-1016 (Aroclor 1016)			7.7×10^{0}	1	B2	Neptocellular carcinoma	Mice/rats, oral; liver
PCB-1221 (Aroclor 1221)			7.7×10^{0}	1	B2	Hepatocellular carcinoma	Mice/rats, oral; liver
PCB-1232 (Aroclor 1232)			7.7×10^{0}	1	B2	Hepatocellular carcinoma	Mice/rats, oral; liver
PCB-1242 (Aroclor 1242)			7.7×10^{0}	1	B2	Hepatocellular carcinoma	Mice/rats, oral; liver
Tetrachloroethene	1.8×10^{-3}	5	5.0×10^{-2}	5	B2	Leukemia, liver tumors	Rat, inhalation; mouse, gavage
Trichloroethene	6×10^{-3}	5	1.1×10^{-2}	5	B2	Lung and liver tumors	Mice, inhalation, gavage

ND = No data
NA = Not applicable
1 Verifiable in IRIS
2 HEAST 1993 and supplements
3 HEAST 1992
4 EPA 1992 - Region IV Guidance.
5 HEAST 1991 - Withdrawn from IRIS. Under review.
6 Calculated from unit risk, see IRIS

TABLE B-10

CONSTRUCTION WORKER HEALTH RISK: INGESTION OF GROUNDWATER

	RME (mg/L)	Noncarcinogenic IF RME (L/kg-day)	Carcinogenic IF RME (L/kg-day)	Subchronic RfD (mg/kg-day)	Slope Factor $(mg/kg\text{-}day)^{-1}$	Hazard Quotient RME	Cancer Risk RME
Metals							
Arsenic	0.16	1.57E-05	2.24E-07	3.00E-04		8.35E-03	6.26E-08
Beryllium	0.001	1.57E-05	2.24E-07	5.00E-03	1.75E+00	2.50E-06	7.69E-10
Cadmium	0.002	1.57E-05	2.24E-07	5.00E-04		6.26E-05	
Chromium	0.01	1.57E-05	2.24E-07	2.00E-02	4.30E+00	6.26E-06	
Copper	0.04	1.57E-05	2.24E-07	3.70E-02		1.69E-05	
Mercury	0.01	1.57E-05	2.24E-07	3.00E-04		2.61E-04	
Nickel	1.15	1.57E-05	2.24E-07	2.00E-02		9.00E-04	
Selenium	0.04	1.57E-05	2.24E-07	5.00E-03		1.32E-04	
Zinc	0.60	1.57E-05	2.24E-07	3.00E-01		3.13E-05	
SVOCs							
Di-n-butylphthalate	0.0047	1.57E-05	2.24E-07	1.00E+00		7.31E-08	
VOCs							
1,1-Dichloroethene	0.0299	1.57E-05	2.24E-07	9.00E-03	6.00E-01	5.21E-05	4.02E-09
1,2-Dichloroethene (total)	0.7340	1.57E-05	2.24E-07	9.00E-03		1.28E-03	
4-Methyl-2-pentanone (MIBK)	0.0177	1.57E-05	2.24E-07	8.00E-02		3.47E-06	
Benzene	0.0037	1.57E-05	2.24E-07		2.90E-02		2.41E-11
Chlorobenzene	0.1919	1.57E-05	2.24E-07			1.50E-05	
Tetrachloroethene	0.4410	1.57E-05	2.24E-07	2.00E-01	5.00E-02	6.90E-05	4.93E-09
Toluene	0.0423	1.57E-05	2.24E-07	1.00E-01		3.31E-07	
Trichloroethene	0.1386	1.57E-05	2.24E-07	2.00E-01	1.10E-02		3.41E-10
Pesticides/PCBs							
4,4'-DDE	0.000123	1.57E-05	2.24E-07		3.40E-01		9.35E-12
4,4'-DDT	0.000354	1.57E-05	2.24E-07		3.40E-01		2.69E-11
alpha-BHC (Lindane)	0.000957	1.57E-05	2.24E-07		6.30E+00		1.35E-09
beta-BHC	0.004150	1.57E-05	2.24E-07		1.80E+00		1.67E-09
gamma-BHC	0.001400	1.57E-05	2.24E-07		1.30E+00		4.07E-10
alpha-Chlordane	0.001057	1.57E-05	2.24E-07	6.00E-05	1.30E+00	2.76E-04	3.07E-10
gamma-Chlordane	0.000687	1.57E-05	2.24E-07	6.00E-05	1.30E+00	1.79E-04	2.00E-10

TABLE B-10

CONSTRUCTION WORKER HEALTH RISK: INGESTION OF GROUNDWATER

	RME (mg/L)	Noncarcinogenic IF RME (L/kg-day)	Carcinogenic IF RME (L/kg-day)	Subchronic RfD (mg/kg-day)	Slope Factor $(mg/kg\text{-}day)^{-1}$	Hazard Quotient RME	Cancer Risk RME
Aldrin	0.001167	1.57E-05	2.24E-07	3.00E-05	1.70E+01	6.09E-04	4.44E-09
Dieldrin	0.000170	1.57E-05	2.24E-07	5.00E-05	1.60E+01	5.32E-05	6.08E-10
Endosulfan	0.000215	1.57E-05	2.24E-07	6.00E-03		5.61E-07	
Endosulfan I	0.000037	1.57E-05	2.24E-07	6.00E-03		9.65E-08	
Heptachlor	0.004150	1.57E-05	2.24E-07	5.00E-04	4.50E+00	1.30E-04	4.18E-09
Aroclor 1016	0.000177	1.57E-05	2.24E-07	7.00E-05	7.70E+00	3.96E-05	3.05E-10
Aroclor 1221	0.002070	1.57E-05	2.24E-07		7.70E+00		3.56E-09
Aroclor 1232	0.010100	1.57E-05	2.24E-07		7.70E+00		1.74E-08
Aroclor 1242	0.000874	1.57E-05	2.24E-07		7.70E+00		1.51E-09
Petroleum Hydrocarbons							
as #2 fuel oil	25,000	1.57E-05	2.24E-07	8.00E-03		4.89E+01	
as #2 diesel	5,930,000	1.57E-05	2.24E-07	8.00E-03		1.16E-02	
as gasoline	0.060000	1.57E-05	2.24E-07	2.00E-01	1.70E-03	4.70E-06	2.28E-11
					Totals	**49**	**1.09E-07**

RME = Maximum detected concentration from Table A-2
IF = Intake Factor (Table A-5)
RfD = Reference Dose (Table A-8
Slope Factors (Table A-9)
Hazard Quotient = RME * Noncarcinogenic IF/RfD
Cancer Risk = RME * Carcinogenic IF * Slope Factor

TABLE B-11

CONSTRUCTION WORKER HEALTH RISK: DERMAL CONTACT WITH GROUNDWATER

	Adjusted RME (mg/L)	Noncarcinogenic IF RME (L/kg-day)	Carcinogenic IF RME (L/kg-day)	Subchronic RfD (mg/kg-d)	Slope Factor $(mg/kg\text{-}d)^{-1}$	Hazard Quotient RME	Cancer Risk RME
Metals							
Arsenic	1.60E-04	3.96E-02	5.65E-04	3.00E-04	1.75E+00	2.11E-02	1.58E-07
Beryllium	8.00E-07	3.96E-02	5.65E-04	5.00E-03	4.30E+00	6.33E-06	1.94E-09
Cadmium	2.00E-06	3.96E-02	5.65E-04	5.00E-04		1.58E-04	
Chromium	8.00E-06	3.96E-02	5.65E-04	2.00E-02		1.58E-05	
Copper	4.00E-05	3.96E-02	5.65E-04	3.70E-02		4.28E-05	
Mercury	5.00E-06	3.96E-02	5.65E-04	3.00E-04		6.60E-04	
Nickel	1.15E-03	3.96E-02	5.65E-04	2.00E-02		2.28E-03	
Selenium	4.20E-05	3.96E-02	5.65E-04	5.00E-03		3.32E-04	
Zinc	6.00E-04	3.96E-02	5.65E-04	3.00E-01		7.92E-05	
SVOCs							
Di-n-butylphthalate	1.54E-04	3.96E-02	5.65E-04	1.00E+00		6.10E-06	
VOCs							
1,1-Dichloroethene	4.79E-04	3.96E-02	5.65E-04	9.00E-03	6.00E-01	2.11E-03	
1,2-Dichloroethene (total)	7.34E-03	3.96E-02	5.65E-04	9.00E-03		3.23E-02	
4-Methyl-2-pentanone (MIBK)	NA						
Benzene	7.81E-05	3.96E-02	5.65E-04		2.90E-02		1.28E-09
Chlorobenzene	7.87E-03	3.96E-02	5.65E-04	2.00E-01		1.56E-03	
Tetrachloroethene	2.12E-02	3.96E-02	5.65E-04	1.00E-01	5.00E-02	8.38E-03	
Toluene	1.90E-03	3.96E-02	5.65E-04	2.00E+00		3.77E-05	
Trichloroethene	2.22E-03	3.96E-02	5.65E-04		1.10E-02		1.38E-08
Pesticides/PCBs							
4,4'-DDE	2.95E-05	3.96E-02	5.65E-04		3.40E-01		5.67E-09
4,4'-DDT	1.52E-04	3.96E-02	5.65E-04		3.40E-01		2.93E-08
alpha-BHC (Lindane)	1.34E-05	3.96E-02	5.65E-04		6.30E+00		4.77E-08
beta-BHC	5.81E-05	3.96E-02	5.65E-04		1.80E+00		5.91E-08
gamma-BHC	1.96E-05	3.96E-02	5.65E-04		1.30E+00		1.44E-08
alpha-Chlordane	5.50E-05	3.96E-02	5.65E-04	6.00E-05	1.30E+00	3.63E-02	4.04E-08
gamma-Chlordane	3.57E-05	3.96E-02	5.65E-04	6.00E-05	1.30E+00	2.36E-02	2.63E-08
Aldrin	1.87E-06	3.96E-02	5.65E-04	3.00E-05	1.70E+01	2.46E-03	1.79E-08
Dieldrin	2.72E-06	3.96E-02	5.65E-04	5.00E-05	1.60E+01	2.15E-08	2.46E-08

TABLE B-11

CONSTRUCTION WORKER HEALTH RISK: DERMAL CONTACT WITH GROUNDWATER

	Adjusted RME (mg/L)	Noncarcinogenic IF RME (L/kg-day)	Carcinogenic IF RME (L/kg-day)	Subchronic RfD (mg/kg-d)	Slope Factor $(mg/kg\text{-}d)^{-1}$	Hazard Quotient RME	Cancer Risk RME
Endosulfan	NA						
Endosulfan I	NA						
Heptachlor	4.57E-05	3.96E-02	5.65E-04	5.00E-04	4.50E-03	3.61E-03	1.16E-07
Aroclor 1016	5.66E-06	3.96E-02	5.65E-04	7.00E-05	7.70E+00	3.20E-03	2.47E-08
Aroclor 1221	6.62E-05	3.96E-02	5.65E-04		7.70E+00		2.88E-07
Aroclor 1232	3.23E-04	3.96E-02	5.65E-04		7.70E+00		1.41E-06
Aroclor 1242	2.80E-05	3.96E-02	5.65E-04		7.70E+00		1.22E-07
					Totals	**0.14029**	**2.40E-06**

RME = Maximum dermal adjusted concentration from Table A-3.
IF = Intake Factor (Table A-6)
RfD = Reference Dose (Table A-8)
Slope Factors (Table A-9
Hazard Quotient = Adjusted RME * Noncarcinogenic IF/RfD
Cancer Risk = Adjusted RME * Carcinogenic IF * Slope Factor

TABLE B-12

CONSTRUCTION WORKER HEALTH RISK: INHALATION OF GROUNDWATER EMISSIONS

	Air Concentration RME (mg/m^3)	Noncarcinogenic IF RME (m^3/kg-day)	Noncarcinogenic IF RME (m^3/kg-day)	Subchronic RfD (mg/kg-day)	Slope Factor $(mg/kg\text{-}day)^{-1}$	Hazard Quotient RME	Cancer Risk RME
VOCs							
1,1-Dichloroethene	6.83E-07	3.13E-02	4.47E-04		9.10E-02		2.78E-11
4-Methyl-2-pentanone (MIBK)	2.74E-07	3.13E-02	4.47E-04	2.29E-02		3.75E-07	
Benzene	1.08E-08	3.13E-02	4.47E-04		2.90E-02		1.40E-13
Chlorobenzene	3.40E-07	3.13E-02	4.47E-04	5.00E-02		2.13E-07	
Tetrachloroethene	6.83E-06	3.13E-02	4.47E-04		1.80E-03		5.50E-12
Toluene	1.23E-07	3.13E-02	4.47E-04	1.10E-01		3.50E-08	
Trichloroethene	6.43E-07	3.13E-02	4.47E-04		6.00E-03		1.73E-12
					Totals	**0.0000006**	**4E-11**

RME = Maximum air concentration from Table A-4
IF = Intake Factor (Table A-7)
RfD = Reference Dose (Table A-8)
Slope Factors (Table A-9)
Hazard Quotient = Air RME * Noncarcinogenic IF/RfD
Cancer Risk = Air RME * Carcinogenic IF * Slope Factor

Note: Only COCs with inhalation toxicity factors appear in the table

TABLE B-13

SUMMARY OF HUMAN HEALTH RISKS FOR GROUNDWATER AT UP OMAHA SHOPS

Receptor/Pathway	Reasonable Maximum Exposure	
	Subchronic H.I.	Cancer Risk
Construction Worker		
Ingestion of Groundwater	49	1E-07
Dermal Contact with Groundwater	0.14	2E-06
Inhalation from Groundwater	0.0000006	4E-11
	49	**3E-06**